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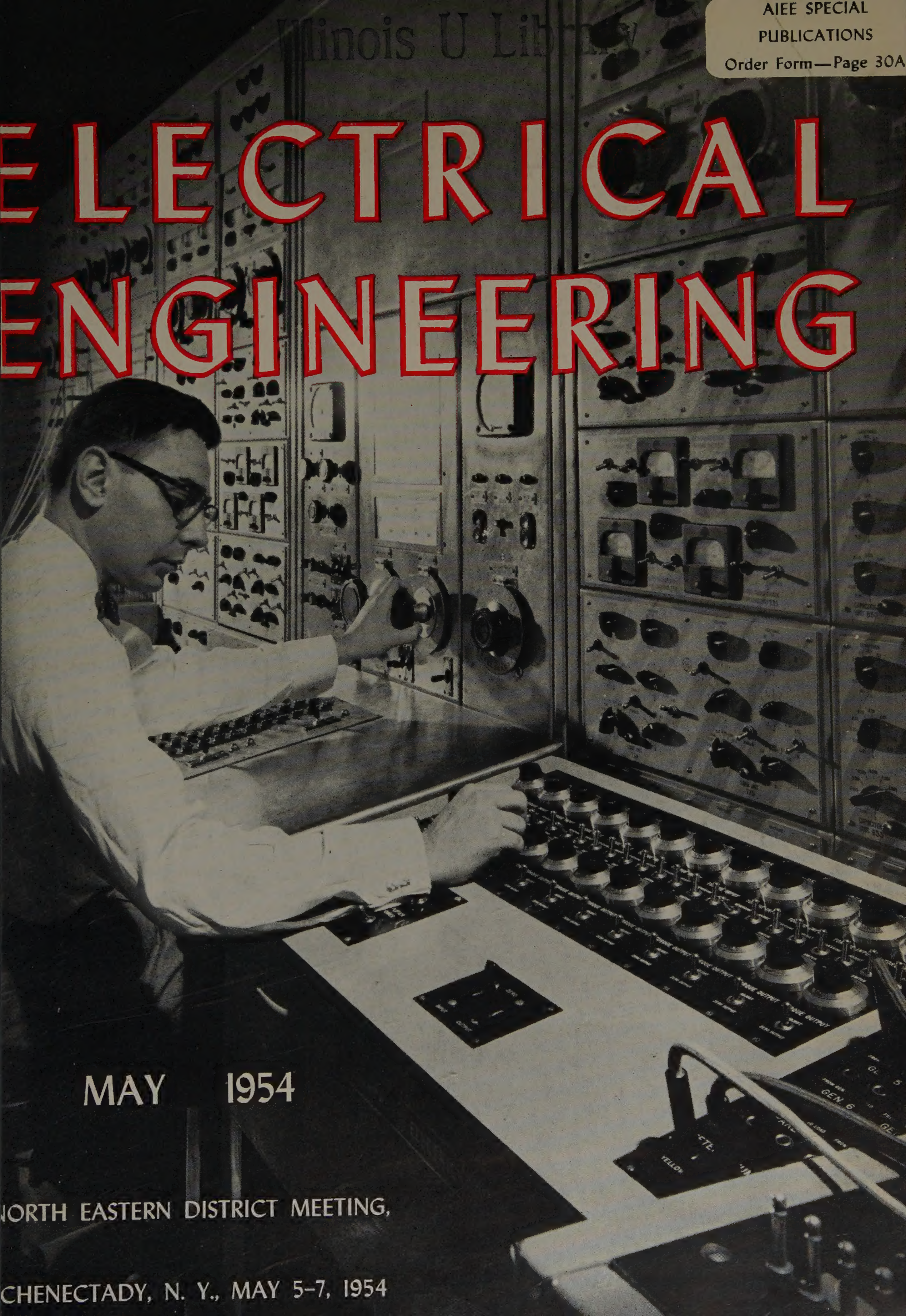
# ELECTRICAL ENGINEERING



MAY 1954

NORTH EASTERN DISTRICT MEETING,

SCHENECTADY, N. Y., MAY 5–7, 1954

# ELECTRICAL ENGINEERING

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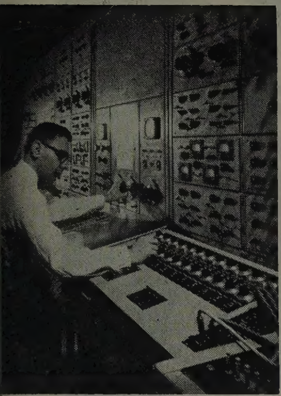

**The Cover:** A swing curve calculator, developed by the General Electric Company, which simplifies transient stability studies. The right hand of the engineer is on the torque output control panel. In the background is the a-c network analyzer with which the calculator is used.



MAY
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## TECHNICAL PAPER DIGESTS





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*The old Roman god Janus lives today in servo mechanisms, instruments, and controls which take past information and use it to guide the future —much as Janus faced backward and forward in time, to symbolize past and future.*

# HIGHLIGHTS........

**Summer and Pacific Meeting.** Featuring a number of timely inspection trips in addition to some 53 technical sessions, this June meeting in Los Angeles offers much of interest to all engineers (*pages 463–5*).

**Research and Development for Defense.** At present about half of the nation's research and development potential is being applied to military purposes, including the related atomic energy programs. To utilize these resources most effectively, the Department of Defense has been reorganized and six new Assistant Secretaries of Defense provided for. Past President Quarles, Assistant Secretary for Research and Development, reports in this issue on the operations and problems of his department (*pages 389–90*).

**100 Curricula in Electrical Engineering.** Many changes have taken place within the past 10 years in the electrical engineering curriculum. In this article the author presents an analysis, based upon recent college catalogues, of the electrical engineering curricula of 100 colleges offering 4-year programs and six colleges which require a 6-year course (*pages 398–400*).

**Letter to a College President.** With the rapid development of state registration for engineers, the Engineers' Council for Professional Development accepted the responsibility for publishing a country-wide list of undergraduate engineering curricula that would meet standards acceptable to the profession. In this "letter to a college president," the author attempts to give a practical summary of some of the important tests of engineering faculty quality (*pages 391–5*).

**Ten Founding Fathers of the Electrical Science—II.** Although better known for his demonstrations of the pressure of air, Otto von Guericke devised and used the first electric machine—an electrostatic generator. Guericke's machine and his experiments with electric conduction and electric repulsion are described (*pages 396–7*).

**Supply of and Demand for Engineers—1953.** The Special Surveys Committee of Engineers Joint Council reports the results and analyses of their recent surveys to determine the number and distribution of engineering graduates in June 1953 and the demand by industry for both experienced engineers and recent engineering graduates (*pages 401–05*).

**EJC and the Engineering Profession.** Although engineers are noted for the accuracy of their daily work, they still have not attained a precise definition of a subject that has become of great importance to the profession, of what constitutes an effective unity organization. The secretary of the Engineers Joint Council points out that the framework for such an organization already has been established in EJC and the developments it is undergoing, and suggests that engineers give it their constructive support (*pages 406–11*).

**A New Milestone in Circuit-Breaker Interrupting Capacity.** For the past 5 years developments have been reported on circuit breakers with increasingly high ratings for systems from 138 kv up to 330 kv. The latest one to be reported has a continuous current capacity of 2,000 amperes and is described in this issue (*pages 421–6*).

**Thermocouple-Type Ammeters for Use at Very High Frequencies.** One of the major problems encountered in measuring currents at very high frequencies is the increase of inductive and capacitive effects of the instruments when measuring currents in the high-frequency bands. An ammeter in which these effects have been overcome is described (*pages 431–5*).

**Progress in Printing Telegraphy.** As commercial and military telegraph communication requirements could not be met completely by existing equipment, this new Model *28* Teletype Direct Keyboard Page Printer Set was developed. It is discussed in some detail following a brief history of printing telegraphy (*pages 412–17*).

**New Fully Supercharged Generator.** This new generator which offers many distinct advantages is discussed in terms of supercharging, rating, cooling of the stator coil, stator core, rotor coil, and air gap, coolers, creepage strength of stator coil ends, blowers, and power plant savings (*pages 435–40*).

**Automatic Flight Control System Using Rate Gyros for Unlimited Maneuvering.** After a general description of the autopilot system and the autopilot-aircraft combination, stability calculations are presented using the *F82* aircraft as an example, and both system components and flight tests are discussed (*pages 443–8*).

**Graphic Analysis of Communication Networks.** The graphical symbols presented have been reduced to the simplest number of available network elements that have proved themselves to be necessary consistently in the analysis and description of a well-developed operating communications network (*page 451–4*).

**All-Electronic 1-Cycle Carrier Relaying System.** Its main functions are phase and ground tripping, carrier starting, and out-of-step blocking. Both laboratory and field tests indicate satisfactory operation under both normal and adverse service conditions (*pages 457–60*).

## News Index



### Bimonthly Publication

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

**Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.**


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# Organization and Need of Research and Development for Defense

D. A. QUARLES
FELLOW AIEE

**In this atomic age an effective military research and development program assumes a special importance. The Assistant Secretary of Defense, Research and Development, presents an over-all view of his office's operations and problems.**

IN RESEARCH and development the objective of the United States, through its Department of Defense, is to keep our weapons ahead of those of potential enemies with the hope that we shall prevent war. In this atomic age we cannot delay the development of new weapons until the enemy strikes. The weapons required to wage war must be developed and integrated into our defense system prior to the start of hostilities. The country must continue to have an effective military research and development program. There is no prospect of peace that would justify letting down this guard.

To this end we must make certain that our research and development program has the broadest scientific and technological base that the country can produce. This is accomplished primarily by our contracts with industrial laboratories, universities, and other nonprofit institutions. About 70 per cent of our research and development funds are spent in this manner, 60 per cent going to industry, and about 10 per cent to universities and institutes. Many of the remarkable advances since 1945 in guided missiles and in warning systems for air defense, for example, must be credited to the imaginative thinking primarily of civilian scientists and engineers.

The Department of Defense at present is spending more money for research and development than ever before in history. Actual expenditures for 1954 will be about $1.3 billion in support of some 8,000 separate research and development projects. During the 4 years prior to Korea, that is, 1947 through 1951, the amount spent averaged $500 million per year. Thus, we now are spending about $2^1/_2$ times the amount we did during the years prior to the Korean War. Such an abrupt change was inefficient. Had the situation been understood better, it could have been planned better; but our history shows that the public tends to turn away from support of the military unless there are clouds on the horizon. Now that the public seems more aware of the threat that faces us, we must not overdo our demands on the Treasury and become overbalanced on the other side.

In utilizing civilian science and technology to the utmost, we cannot monopolize the civilian scientists and engineers. At present, about half of the nation's research and development potential is being applied to military purposes, including the related atomic energy programs. It is doubtful that any higher level could be achieved without damage to the essential civilian economy. Under these conditions, it is incumbent on the Department to use its research and development funds and resources with increased effectiveness.

The plan approved by the Congress in June 1953 for the reorganization of the Department of Defense clarified the responsibility of the Secretary of Defense for the management of the military departments and provided for six new Assistant Secretaries of Defense, three of whom would cover the various activities pertaining to materiel; that is, research and development, applications engineering, and logistics and supply.

While the reorganization plan as a whole became effective on June 30, 1953, the problems involved were so fundamental that the Department only now actually is getting under way in the new setup. There are two cardinal principles: first, that the military departments be given the maximum responsibility for their research and development programs and the maximum latitude in planning and organizing them, consistent with the over-all restraints, such as budget and co-ordination restraints, which the Department of Defense must apply; and second, that the military establishment make best possible use of the technical advice and assistance available to it from national scientific and engineering resources. The field of military research and development is, of course, very broad. To get parts of manageable proportions, it was necessary as a first step to subdivide the field into a dozen or so areas. To achieve fiscal control and interdepartmental co-ordination, co-ordinating committees are being set up in each of the research and development areas. These are in-shop committees consisting of high-level representatives of those military departments having programs in the field, together with representatives of the Assistant Secretary for Research and Development. These committees will be charged with the planning and administration of the program. They will take responsible action, with the understanding that dissents within the committee will be referred to the Assistant Secretary of Defense for Research and Development for adjudication.

Set opposite these in-shop co-ordinating committees will be panels of technical consultants appointed from among outstanding scientists and engineers in the dozen or so areas of technology. From these panels, groups will be

Essentially full text of an address presented before the National Security Commission of the American Legion, January 28, 1954.

**D. A. Quarles**, Assistant Secretary of Defense, Research and Development, Washington, D. C., is a past president of the Institute.

drawn for the study of designated problems or programs and for technical advice and assistance to the co-ordinating committees, the military departments, or the Department of Defense in their administration of the program. Such advisory panels will be asked to report their findings, and particularly any dissents they may have from the technical plans and programs of the departments, so that again such dissents may receive the same kind of consideration as dissents within the co-ordinating committees. As has been mentioned, charters now are being issued for these committees and panels and they are being manned and set to work. The Research and Development Board experience has been of value in establishing the new organization. As would be expected, therefore, it departs in many important features from the Research and Development Board setup yet retains many of its values.

## AIR DEFENSE

In recent months, particularly following the announcement of a Russian thermonuclear test, much has been said on the radio and in the press about the adequacy, or otherwise, of the air defense of the North American continent. In spite of all the criticism, the national interest would not be served best by having the Department of Defense enter into public debate on the technical aspects of this matter. We had a very substantial continental defense program before the events of the late summer. Moreover, this was backed up by a very substantial research and development program that frankly recognized the technical deficiencies in the way of achieving an airtight defense. Any concept that the country was caught napping is wholly unfounded. We must recognize, however, that the technological race we are in has some of the aspects of a chess game in which each player makes his moves and countermoves to dispose his forces to maximum advantage. There is no end to such moves, no ultimate answer. Technically there is always a countermove for each move, although it may be difficult and costly.

There are two handicaps placed on the United States in this race. The first is that our moral code which commits us to a nonaggressor role allows our adversary to choose at any time whether the race will be a 100-yard dash or a marathon. The second handicap is inherent in our democratic policy of keeping the public informed. In so doing, however, we hand our adversary a mass of information about our plans and equipments without any corresponding co-operation on his part. While these are very substantial initial handicaps, they are in final analysis not handicaps at all. Keeping to the nonaggressor role is an essential element of our position in the court of world opinion; and keeping the public informed is essential, at least some of it is essential, to that common understanding that is fundamental to unity of purpose at home. All of this is just part of our faith in our decent, honest, free-enterprise democratic system. It is nothing new that the better system should have to enter the race with a few handicaps. One almost might say paradoxically that the handicaps assure the victory.

Under these circumstances, some things stand out clearly. First, we must make the 100-yard choice, the quick showdown, a very unattractive choice, and the powerful Strategic Air Command, backed up as it is by a potent atomic weapons program, is a most important and a deterring influence in this regard. Second, we must bend every reasonable effort toward a tight continental defense. That is, it would be unreasonable to invest large sums in obsolescent arrangements when much superior ones are in the offing. We must leave these judgments to those who can judge the issues in their technical and logistic detail. We must recognize too that the race very well may be a marathon which requires us to husband our resources for the long pull.

It is not at all certain that the public understands the extent of the effort necessary to develop and maintain a complex military system such as the Strategic Air Command or the air defense system. The *B-52* and *B-47* strategic bombers and the NIKE missiles are just individual pawns in this gigantic chess game. Yet each requires years for the process from research and development through to operational capability. It is not a process that can begin in August and be finished in December.

For example, consider the NIKE development. It was 1945 when the U. S. Army first asked Bell Telephone Laboratories for a paper study of the problems involved in developing an antiaircraft system adequate to counter the speedy, maneuverable, high-speed aircraft then in existence and on the drawing boards. The study was followed by a development contract, and the Douglas Aircraft Company became a full partner with responsibility for the design of the missile itself and the launching system equipment. Nearly 5 years were required to solve the technical design and production problems posed by the NIKE system. Although missile firings without guidance control were started in 1946, successful test firings of the controlled missile as a system were undertaken only 2 years ago. The first operational unit will be installed in the near future at Fort George G. Meade in Maryland. The missile and control system has more than 1,500,000 individual parts produced by several hundred contractors in more than 20 states.

Our other major weapons follow this same pattern. It is inherent in the development of the complex systems coming from our advanced science and technology. Due to the nature of our technology and the threat facing us, we must have a strong, continuous research and development program. With our reorganization in the Department and with steady, continuous support for research and development, we should be able to achieve our objectives.

We are fortunate that the President, the Secretary of Defense, and the leaders in both houses of Congress have a keen appreciation of this necessity. The reorganization of the Department of Defense was a constructive move. The challenge is to make the most of our opportunities. The one great danger is that the public will forget—as it has between other wars. Those of us who understand this problem can render a vital public service by helping to convince the general public that the price of peace is a continuing program of preparedness. The Defense research and development program is the means of mustering our science and technology to this vital purpose.

# Letter to a College President

H. L. HAZEN
FELLOW AIEE

**In view of the increasing interest in the accreditation of engineering curricula, this "letter to a college president" attempts to set forth, informally but factually, the types of questions that a visiting committee of the Engineers' Council for Professional Development would consider in its efforts to determine the acceptability of an engineering program for listing by the Council.**

STRANGELY enough, the title is not an attempt at eyecatching fiction. The latter part of this article is in fact the text of a letter written to the president of a small engineering college, where the engineering curricula had been appraised by the Engineers' Council for Professional Development (ECPD) as marginal. This president, in common with nearly all of his fellow presidents, is striving with great energy, earnestness, and sincerity to improve his engineering school in the face of extremely serious difficulties. Not an engineer himself, he is not entirely sure what ECPD standards actually are in practice. Especially he feels uncertain in his mind as to what will be recognized in the profession as a good faculty. This letter was written in the attempt to set forth informally but factually the kind of questions that an ECPD visiting committee to the institution asks as a part of its study to determine the acceptability of an institution's engineering curricula for ECPD listing.

Before plunging into what is really the heart of this problem associated with accreditation, namely, faculty qualifications, let us briefly take a somewhat broader view of the activity as a whole. Although the accreditation procedure for engineering curricula has been in effect for about 20 years, interest and concern about it has shown a sudden upsurge rather recently, stemming from several sources.

## PRESENT INTEREST IN ACCREDITATION

ON ONE FRONT, college presidents faced with a rapidly increasing number of organizations claiming accreditational jurisdiction over educational programs at the college level, numbering in the case of a full university something like 300 separate agencies, have staged an organized revolt in the form of a voluntary organization called the National Commission on Accreditation. These 300-odd agencies range in quality and character all the way from those established and operated by nationally recognized organizations of professions—ECPD is an example in engineering—whose activities were recognized as legitimate and in the interest of establishing adequate professional standards, to proprietary organizations charging high fees and using methods that in some cases fall little short of blackmail. An interesting sequel of this activity, involving ECPD, is mentioned subsequently.

Another factor that has increased recent attention to ECPD has resulted from ECPD's instruction to its working group, the Education Committee, to raise its minimum standards of accreditation for a curriculum. Such a stiffening of standards is bound to have substantial repercussions.

A third and current source of extremely active interest in engineering accreditation is the draft of the report of the Committee on Evaluation of the American Society for Engineering Education (ASEE) which has been circulated widely in preliminary form to serve as a basis for discussion. A rather small portion of this preliminary draft contained certain suggestions and recommendations relating to accreditation that have raised a tempest across the country, so to speak, at the expense of consideration of what are probably far more important portions of this committee's report. In any case its tentative recommendations relating to accreditation have added to this interest and activity.

## WHY ACCREDITATION?

BUT WHY accreditation in the first place and what is it all about? Without attempting to answer this question fully, a few of the salient points can be mentioned. In engineering the rapid development of state registration for engineers in the 1930's threatened to produce 48 separate lists of approved engineering curricula, which would be regarded by state boards as offering acceptable educational opportunity. To avoid the obvious consequences of such a situation, the National Council of State Boards of Engineering Examiners appealed to the engineering professional societies for help. As a result, ECPD accepted the responsibility for publishing a country-wide list of undergraduate engineering curricula that met standards acceptable to the engineering profession. In 1932, Dr. Karl T. Compton, then president of the Massachusetts Institute of Technology, was asked to form and be chairman of a Committee on Engineering Schools to develop and administer a program of inspection of institutions requesting it, that would lead eventually to the ECPD list. The resulting program and the principles under which it is administered appear in each "Annual Report of the Engineers' Council for Professional Development," available from ECPD headquarters, 29 West 39th Street, New York 18, N. Y. These principles will not be reviewed here except to say that no specific standards are set.

## STANDARDS FOR ACCREDITATION

THIS ABSENCE of definite, explicit, quantitative standards of acceptability is at once the occasion for considerable criticism of this ECPD activity, and at the same time regarded as one of the great strengths of this ECPD program

**H. L. Hazen**, dean of the Graduate School, Massachusetts Institute of Technology, Cambridge, Mass., is chairman of Region II Education Committee, Engineers' Council for Professional Development.

by those who have gone into the subject deeply over the years. Stripped to its essentials, the real working standard for the ECPD accreditation program is the successively exercised judgment of three groups. These groups, as explained subsequently, are the inspection committee for the particular school, the Education Committee of ECPD, and the Council of ECPD. When some institution's program is found to be at or below the minimum acceptable level, such standard quite naturally is criticized as being a poor or nonexistent standard and the question is asked, "How can an institution know how to meet a standard defined so tenuously and vaguely?" The answer simply is that engineering education involves so many and varied elements, some of the most important of which are intangible, and which differ so greatly from school to school, that great flexibility is essential if unhealthy constraint is to be avoided. Such elements include the curriculum, its composition, level, and relative emphasis of various fields including general education, science, engineering science, and engineering applications; the kind and level of performance that are required of students; the physical facilities of laboratories, classrooms, offices; intellectual and personal quality and the preparation of students; and, of course, most important of all, the character and quality of the faculty, together with the nature of the administrative support given to this faculty. These various elements, and others, differ substantially from institution to institution in such a way that any set of specific quantitative criteria appears to fail of general applicability.

In practice, the only cases in which the judgments of these three successive groups concerning an institution differ are those in which the over-all quality of the program is clearly recognized by all these groups as marginal. In such a case one group may decide that the quality is marginal plus and recommend accreditation, while a subsequent group decides that it is marginal minus and recommends nonaccreditation. Thus what is actually a very small difference in appraisal results in an apparently major difference in result. Such an effect would be important if an institution really desired to work near the marginal level. However, one never finds an institutional president with the point of view to ask, "What is the passing grade, because I want my institution to get 1 per cent above the passing grade?" The president wants to have his program not just acceptable but well up on the quality scale. In the light of these standards, the objection that a decision has fallen two different ways at two different times, quite apart from the always changing character of any program, clearly indicates that this program is in any case uncomfortably near the minimum standard, and therefore unsatisfactory by the president's own standard.

## ECPD ACCREDITATION PROCEDURE

Consider briefly how this accreditation activity actually is carried out. The ECPD is one of the major groups concerned with the engineering profession as a whole. It is "a conference organized to enhance the professional status of the engineer through the co-operative efforts of the following national organizations, concerned with the professional, technical, educational, and legislative phases of engineers' lives: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, AIEE, Engineering Institute of Canada, American Society for Engineering Education, American Institute of Chemical Engineers, National Council of State Boards of Engineering Examiners."

Accreditation of undergraduate engineering curricula is one of a number of functions performed by ECPD. This function is administered actively by the Education Committee (formerly the Committee on Engineering Schools until October 1950). This committee now is composed of 16 members, including a general chairman, a chairman and vice-chairman for each of seven geographic regions into which the country is divided, a member-at-large, and a representative of the Engineering Institute of Canada, although Canada is not included at present in accreditation.

In brief the mechanics of operation are as follows. Upon receipt of an invitation from an institution (ECPD never inspects except on invitation) the institution is sent a comprehensive questionnaire and a bill. The regional chairman or vice-chairman assembles an inspection team from a list of engineers and educators approved by the constituent professional societies of ECPD, and arranges for their visit to the institution, usually requiring 2 days. In general, there will be one member of the inspection committee for each curriculum submitted for consideration. After the inspection each inspector writes an individual report on the area assigned to him. These reports are submitted to the inspection committee chairman, who in addition to writing his individual area report prepares an over-all report and recommendations. The recommendations normally have been discussed very fully and carefully by the inspection committee at the end of the visit.

This inspection committee report is passed on to the regional chairman, who in turn reviews and prepares his recommendations on all of the institutions visited during the year prior to the meeting of the Education Committee in June each year. This meeting usually is held immediately before or after, and at the location of the annual ASEE meeting. At this meeting final recommendations to ECPD are prepared on the basis of a thorough review of each institution, careful intercomparisons on a nationwide basis, and action of the entire committee. A second meeting of the Education Committee immediately before the October or late September meeting of ECPD considers cases not ready in June and results in a complete list of recommendations to ECPD for the year, which then are acted upon by the Council of ECPD in closed executive session. Each official action thus achieved is transmitted immediately to the institution concerned, together with a statement in general terms of some of the more important observations of the inspection committee. The inspection committee's report itself is a confidential ECPD document, but the president of the institution is told that he may ask the regional chairman for further information if he so desires.

## COLLABORATION WITH REGIONAL ASSOCIATIONS

Before examining the sequel of notification of ECPD action, consider for a moment a development growing out of the National Commission on Accreditation activity.

Stripped of historical complications, an experimental procedure is now in operation in which one of the so-called regional associations, the Middle States Association of Colleges and Secondary Schools (MSA), works with accrediting agencies of the various professions in a collaborative inspection procedure. This can save the institution much complication and effort. The engineers may take a certain pride in the fact that they were the profession to which initial overtures were directed and with which the development of the collaborative procedure has proceeded fastest and furthest. Several joint inspections now have been completed by ECPD and the MSA to apparent mutual advantage of ECPD, MSA, and the institution.

In this joint operation, the ECPD team functions in a dual capacity. In its ECPD role it functions essentially as in any ECPD visit, including confidential reporting to ECPD on undergraduate engineering curricula only. In addition the ECPD team functions as an integral part of the larger MSA team covering, at the request of MSA, other engineering or related fields such as nonaccredited engineering curricula, extension work, graduate work, etc., which lie outside explicit ECPD interest. In turn MSA experts in such fields as administration, finance, plant, admissions, library, English, humanities, social sciences, physics, mathematics, and chemistry provide the ECPD teams with appraisals of these areas that are more searching than ECPD normally could obtain when acting alone.

MSA presents its report to the institution in its normal way including a component report from the regional chairman of the ECPD which he prepares from the ECPD report in such a way as to apply to MSA objectives without compromising confidential aspects of ECPD reporting or recommendations for ECPD accreditation.

Thus far MSA is the only regional association officially collaborating with ECPD, but this well may establish a general pattern for other regions, if and when such regional associations request collaboration.

### WEAKNESSES—A PROBLEM IN HUMAN RELATIONS

To return to ECPD accreditation procedure, after the institutions have been notified of the ECPD action taken on their curricula at the October meeting, the presidents are invited to ask for information additional to that in the official ECPD statement, and many do regardless of the status accorded their program, whether unacceptable; marginally acceptable, as evidenced by short-term accreditation; or satisfactory, shown by 5-year accreditation. When the institution has been judged marginal or submarginal, some of the most difficult, exacting, and occasionally unpleasant, work of the operation arises. No president is pleased at serious criticism of his institution. This is a completely human reaction, intrinsic and unavoidable. Delicate problems in human relations of the most serious sort are inherent in such a situation, but with normal basic good will on both sides the ultimate result usually is constructive and rewarding.

Perhaps the most serious problem arises from an entirely innocent lack of understanding and appreciation on the part of a responsible institutional administrator, whose own professional field lies outside engineering, of what characterizes a strong operation in engineering education. The key element, as stated and as cannot be emphasized too strongly, is the faculty. Other elements are involved, but these follow more or less naturally from the presence of a good faculty that is given good administrative support. Frequently when such an institutional president comes to understand the criteria by which the engineering profession recognizes high ability, and also the very serious financial and environmental problems that must be solved to attract and hold such people, the program is well on its way to meeting acceptable levels.

In a context such as the foregoing, the letter whose text constitutes most of the remainder of this article was prepared and sent. Two paragraphs have been added near the end, otherwise the rather informal original text has been retained with only minor editing. This letter makes no pretense of being exhaustive; rather, it attempts to give a practical summary of some of the important tests of engineering faculty quality.

## From the Letter to the College President

The important quality that we look for in faculty is evidence of professional stature and competence, including the kind of competence that makes a good teacher. Evidence of such stature and competence may take any of a number of forms or combination of these. In the case of a man in his 30's, or even 40's, we are interested to see if he has a doctorate, since if he has, it is evidence that he has had sufficient scholarly interest to go on for graduate work and research. But the doctorate of itself is neither necessary nor sufficient evidence of the quality for which we are looking. It is not necessary because there are many young men of first-rate ability who have elected not to take graduate work. We usually ask how it is that a man who is interested in education has not taken the rather natural route of graduate work and the resulting advanced degrees, but we are quite willing to be convinced that there are reasons not affecting his qualifications. On the other hand, the man may have the qualifications to earn and actually hold an advanced degree and still not have the personal qualities or indeed the effectiveness in professional work that would qualify him well as a faculty member. Thus while we use the doctorate degree as a quick, rough-and-ready indicator, it is an indicator rather than a measure of the qualities for which we are looking.

In an older man, whose formal education took place at a time when advanced degrees in engineering, especially at the doctorate level, were comparatively rare, we would have even less basis for insisting upon a doctorate degree. In such a case we nearly always have to look to other criteria.

In a faculty of several members in a given department we are likely to expect to find from one to several members holding doctors' degrees, if the faculty is really good. However, it is perfectly possible that such professional qualifications as I will mention are sufficient to show excellence.

### PUBLICATION AND RESEARCH

Publication is another indicator of professional stature. Here again, the mere fact that a man has published a

number of papers does not in itself have significance. One asks: were the papers good, did they make significant contributions, were they well regarded by competent men in the field, are any of them recent publications? If the publications are in the form of books, we ask, is the book recognized as making a genuine professional contribution either to the field or to the teaching of the field? On the other hand, is it merely a compilation in different form of material already available in book form to the profession?

Another indicator is the kind, if any, of professional work upon which the man currently is engaged. Does he have any investigatory activity under way? One important form of such investigatory activity is research. Such research usually though not invariably would be carried out in the institution, either with institutional funds or some form of sponsorship from industry or government. If such work is under way, is it basically just testing? Is it puttering in its professional standards, or is it work that really digs into some new area and offers some promise of real contribution to the profession? This work may be applied or of a fundamental character. If applied, it still should have real intellectual challenge, involve imaginative exploration of new ideas, and in general be of such nature that if it is well carried out, it should lead to publication welcomed by the accepted professional journals in the field. Such research always is stimulated and facilitated if the staff member attracts graduate students as co-workers in such a project. Graduate students, however, are not essential. Such a project need not be large. In fact it may be quite modest in its physical and fiscal dimensions. The important point is the quality of intellectual effort involved and the professional significance of the investigation.

The development of specific hardware may or may not represent good research activity in engineering. The test is not whether or not the product is produced in pilot model or other form, but rather the kind of professional effort required and the level of professional competence demonstrated.

Another possibly significant kind of professional work is consulting. We ask, is the man doing any consulting work? If he is, we again ask, is it of a routine character or does it involve substantial responsibility? Is it concerned with some new development, or is he merely doing routinely some handbook arithmetic application of well-known principles?

## QUALITY OF TEACHING

Another indicator, and a very important one, is the kind of teaching that a man is doing. Is he continually revising the subjects that he teaches in response to the impact of new developments? This does not mean, for example, asking in the field of electrical engineering whether he is teaching television or not; rather it means, is he taking into account in his selection of the areas in the fundamental engineering science that he treats, the kinds of principles that one must understand if he is to have a basic understanding of the field of television? A continuing evolution of the teaching of even so elementary and fundamental a subject as electric circuit theory or electric field theory is evidence of scholarly and active mind that we like to see in a teacher. We are skeptical of the man whose course has not changed very appreciably in the last 10 years in the orientation, outlook, and selection of subject matter. Again this most emphatically does not mean that we expect a professor to teach applications. It does mean that we expect his handling of fundamental courses to reflect, in the selection of material, the selection of illustrative problems, and in the associated laboratory work, the needs of the fields that are active today in practice.

The kind and quality of a man's teaching technique and the effect this has on his students are significant. Here the evidence is often hard to get and necessarily rather intangible. Nevertheless there are often indicators as to whether the man's class and laboratory teaching is of a character to stimulate the imagination of his students, to develop their initiative, to challenge their abilities, to broaden their outlook, to impose real responsibility on the student. The contrast with this is the teaching that conscientiously but without imagination, ingenuity, or contribution of its own, follows the content of some standard textbook. The problems a professor gives to his students are often very revealing of a professor's professional outlook and the kind of influence that he is bringing to bear on his students. The home problem or laboratory exercise designed to pique the student's curiosity or make him think out something different from what the textbook has shown, is a good indicator.

The level or penetration of a professor's teaching provide meaningful indicators of his intellectual stature and the quality of his influence. Here we ask the questions, does his work have a large qualitative content, or does he emphasize more strongly the analytic, the mathematical, the scientific aspects? Does he cover the theory somewhat apologetically and superficially merely to satisfy a conscience before getting to problem work and applications? Does he try to get his students to understand the basic mathematical theory at least at an elementary level? Does he make free use of the calculus, and, in the appropriate fields, even elementary differential equations, or does he stick to arithmetic and algebra alone? If he uses calculus, does he really understand it himself and use it with a reasonable degree of rigor? We feel that engineering school offers an almost unique opportunity for a student to get the underlying theory and science, and that this school time is to a considerable extent wasted if it is devoted to qualitative, descriptive material in lieu of fundamental theory.

We, of course, recognize the importance of the mature individual of broad experience and notable wisdom who can convey to his students an important contribution to their character and to their entire outlook on their profession and life. We should not underrate such a person when we actually find him, but neither should we make the mistake of attributing these high qualities to the genial, personable good fellow who has long lost (if he ever had any) his vigor and his technical acuteness. We must insist upon really acute and penetrating intellectual attributes and general technical astuteness of a superior sort to make our professor eligible for the true elder statesman category.

## OTHER PROFESSIONAL ACTIVITIES

Leaving teaching and turning again to other areas of activity, another indicator is the degree of participation of the faculty member in his professional society activi-

ties. By participation I mean not only attendance but taking an active part in the meetings and activities. The fact of participation itself is not sufficient. One needs to know whether his participation relates to significant ideas and issues, or whether it is shallow and conventional. In what repute is the man held by his professional associates over the country? Is he known to them because of his professional contributions, or is his name unfamiliar?

Industrial experience, of course, can be an important measure of professional qualification. We need, however, to look at the nature and character of this experience very closely to determine its relevance to engineering teaching. Thus we look primarily not at the number of years, or even the administrative responsibility that a man may have carried, although these are not entirely unpertinent, but rather at evidence of intellectual qualities and activity that we feel are important in a teacher of engineering. Has he been responsible for significant new developments? Is he the sort of person who can be articulate in relating his engineering works to the underlying engineering science clearly and logically? Has his work been such that he has kept his underlying science and engineering science alive and up-to-date? Is his exposition clear and logical? Many practical engineers who achieve fine results do so by a kind of intuitive sense which, no matter how successful for a practical engineer, falls flat as far as effectiveness in teaching engineering students is concerned.

Looking now at the over-all appraisal, one cannot expect to find a high score for very many of the people on all of the foregoing indicators of professional stature and competence. A good man, however, will score rather well on more than one of the foregoing categories, including one or more outside of teaching; the better the man, the higher his score and the more categories in which he will have a high score. Furthermore, in a good and well-rounded department faculty all of these qualities are present though seldom in any single individual.

One final word regarding the doctorate is perhaps not out of place, especially as the importance of this degree as a qualification for faculty appears to be so widely misunderstood. Doctorates are fine in their place, and they have a place, a place of increasing importance in engineering education. But let us neither give them too much weight, nor ignore them completely. Rather let us try by all the measures we know to determine whether this man is one to whom we really wish to expose our engineering students.

### TEAMWORK AND LEADERSHIP

Thus far we have emphasized primarily the qualities of the individual person at which one looks in attempting to appraise a faculty member. A fine faculty, however, consists of much more than a group of individuals and individualists, who would qualify well according to the foregoing criteria. The element of team play and team spirit is almost as important in an engineering faculty as it is on a college football team. Do the various faculty members work together harmoniously and co-operatively? We must not be misled by the dulcet sound of the words "harmonious" and "co-operative." A very important test of these qualities is the ability of these individuals to differ with each other vigorously and earnestly in an intellectual sense, and indeed on problems of a more philosophic character, but to maintain in all this a degree of objectivity and personal good will that makes the friendly golf match or wilderness fishing trip together just as characteristic as strongly expressed differences of opinion and judgment. One looks for evidence of fairly achieved compromise in the common core of earlier courses, and expects the curriculum as a whole to have a unity and singleness of purpose that provides strength. At the same time one looks for the tolerance that permits fine ability and special competence to have its head in elective subjects.

One also looks for evidence of good leadership, leadership that insists upon a sound, well-rounded, forward-looking pattern in the curriculum and program. Sometimes a fairly firm hand is indicated from a dean to assure that enthusiastic individualists take sufficient time and thought in joint and co-operative effort to assure that their program as a whole makes sense, that it points toward worthy and forward-looking objectives, and considers adequately and imaginatively the advancing fronts of the professional field. But through all the activity there should be evident a spirit of good will, of willingness for some personal sacrifice in the common good, and a sense of pulling together that nevertheless encourages expression of individual ability.

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This, then is a letter to a president of a relatively small engineering school, a president whose objectives in the immediate future if they are to be realistic must not be too ambitious. If, over a period of years, he can develop a faculty that will score reasonably well on the criteria that have been suggested and can give his faculty reasonable support, he will have a good, though modest, school.

Those institutions that have higher ambitions and have the resources, actual or potential, to back these ambitions, will reach, of course, even higher in their search for faculty to produce and sustain an outstanding program. The smaller and more modest engineering schools, however, have a very important function indeed to perform in this country, even though they may not be known for as spectactular or outstanding accomplishments as a few of their sister schools.

Indeed, many of the larger institutions, in terms of student numbers, must be content to do, and indeed may take justifiable pride in doing, a job of the "good" sort implied by the letter to this president. A student who has come under the influence and inspiration of a faculty who score well on the criteria that have been given will be able to take his place in industry or in graduate work satisfactorily if he has proper intellectual and personal qualifications.

This college president now is left to his difficult task of recruitment, of solving those human problems that appear as soon as one undertakes to infuse new life and a more sophisticated kind of activity into a well-intentioned but phlegmatic and modestly equipped faculty, and to provide the financial base for salaries that are necessary to attract and hold men of the sort that he must have. This president's task is really difficult. Make no mistake. Yet, it has been done and is being done successfully. It is hoped and expected that more institutions will rise to this challenge.

# TEN FOUNDING FATHERS OF THE ELECTRICAL SCIENCE

# II. OTTO von GUERICKE

## *and the first electric machine*

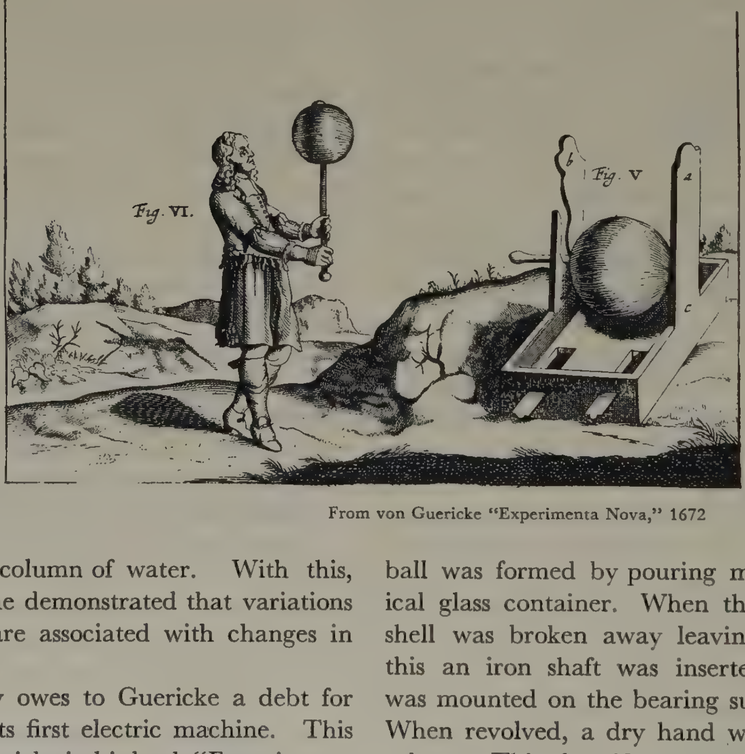
BERN DIBNER
FELLOW AIEE

**Otto von Guericke constructed the first electric machine—an electrostatic generator—by means of which he generated the first visible and audible electric discharges. With the new machine he observed the behavior of the electric charge along the electrical body, and took the first step in the ever-extending process of electric transmission of power.**

ALTHOUGH BETTER KNOWN for his experiments in determining the pressure of air than for his contributions to the science of electricity, it was Otto von Guericke who devised and used the first electric machine, an electrostatic generator.

Guericke was active both politically and scientifically in the turbulent times of the mid-1600's; he participated in the disastrous Thirty Years War and was the burgomaster of Magdeburg, Prussia, for 35 years. He invented the first air pump about 1645 and in the following 10 years improved its construction and inspired Robert Hooke and Robert Boyle in England to advance its use. He devised a stack of sealed brass tubes to demonstrate the height at which air pressure will support a column of water. With this, the first water barometer, he demonstrated that variations in the top of the column are associated with changes in weather.

The science of electricity owes to Guericke a debt for his invention, in 1660, of its first electric machine. This machine is described by Guericke in his book "Experimenta Nova Magdeburgica," published in Amsterdam in 1672. Here also are described electric conduction and electric repulsion, which had been described earlier by Cabeo in 1629. Gilbert not only had failed to notice repulsion, he denied its existence; Guericke recognized the significance of repulsion and experimented with it. He noticed that after the sulphur globe had been electrified by rubbing, a body first would be attracted to it and, on contact, be repelled. If this body then touched any other body but the sulphur globe it again would be attracted to the globe. Guericke had constructed his machine so that the globe on its shaft could be lifted from its supports and carried about the room as shown in the diagram in his book. He observed that a feather floating in the air would be repelled by the globe, that the feather preferred attraction to "the points of any object whatsoever before it, and it is possible to bring it to where it may cling to the nose of any one." Pointed conductors therefore were most effective in attracting an electrified body.



From von Guericke "Experimenta Nova," 1672

The construction of this electric machine, the first rotating generator, was basically a sulphur ball revolving on a shaft. The ball was formed by pouring molten sulphur into a spherical glass container. When the sulphur cooled, the glass shell was broken away leaving its spherical form; into this an iron shaft was inserted and the assembly then was mounted on the bearing supports of a wooden frame. When revolved, a dry hand was applied to the revolving sphere. This electrified the sphere which then was shown to attract paper, feathers, lint, and other light objects. It also was noted that these adhered to the sphere as it rotated and it prompted Guericke to compare it to objects clinging to the surface of the earth. He thus assigned an electrical cause to the attraction of things to the earth's surface as against Gilbert who believed this attraction to be of magnetic origin. He also noticed that there was agitation in drops of water brought near the electrified sphere and that the attractive effect was dissipated when

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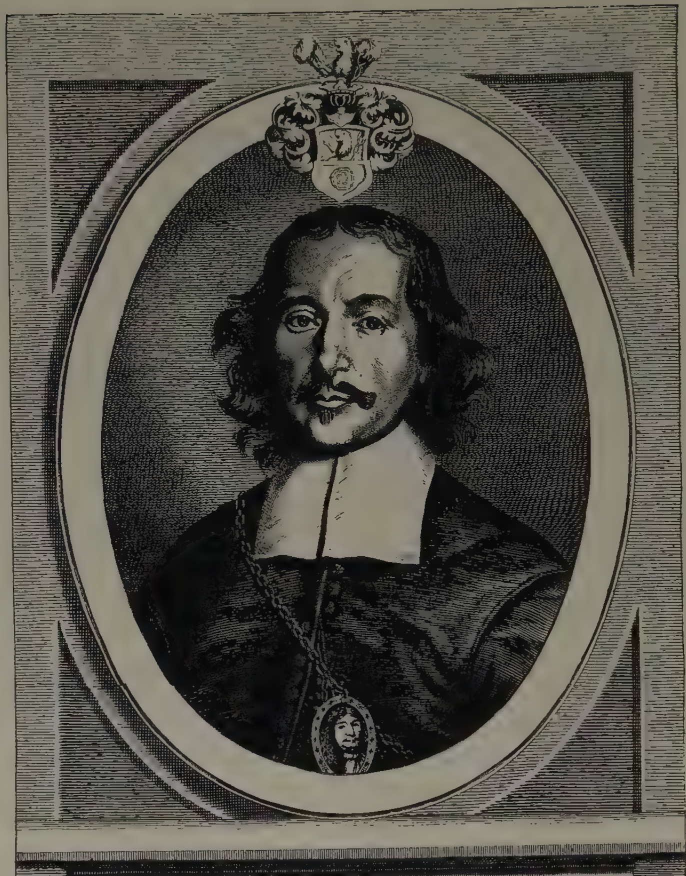
brought near smoke or fire. Most important of all, Guericke observed small sparks in the discharge and heard their crackling sound. Thus, for the first time, someone actually saw and heard what heretofore had been manifested only as a gentle attractive force. Guericke noted that "if you take the globe with you into a dark room and rub it, especially at night, light will result"; further, "there is likewise a virtue of sound in this globe, for when it is carried in the hand or is held in a warm hand and thus brought to the ear, roarings and crashings are heard in it." Dr. Wall of London, reporting on some experiments in 1708 to the Royal Society, in which he had produced flashes of light and a crackling sound by drawing a long piece of amber through a piece of woolen material, made the prophetic observation that these sparks, some an inch long, resembled thunder and lightning.

With the new machine Guericke observed the repulsion of what we would call similarly electrified bodies. One such body which first had been attracted to the sphere now was repelled by the sphere but attracted to other bodies. It then was attracted again to the sphere after having come in contact with a finger or upon touching the ground. He also observed that a feather would move up and down between sphere and ground. Further observation showed that an electric charge traveled out to the end of a linen thread and that bodies became charged even if only brought close to a charged sphere. The phenomena of both electric conduction and induction thus were observed and demonstrated by Guericke; they became the subject of extensive investigation by later electricians. Guericke had succeeded in "showing ocularly that the sulphur globe, having been previously excited by rubbing, can likewise exercise its virtue through a linen thread an ell (45 inches) or more long, and there attract something." Gilbert had noticed the extension of magnetic influence along a magnetized bar; Guericke saw the same behavior of the electric charge along an electrified body.

Thus, by placing a linen thread in contact with the electrified globe, Guericke took the first step in the ever-extending process of electric transmission of power, albeit the distance traveled was little more than a yard. Stephen Gray, a half century later, extended the span of transmission to over 250 yards of linen thread. It remained for Dufay, writing in 1733, to call the attention of the Royal Academy of Science of France to the importance of Guericke's electrical discoveries.

It must be noted that the work of Guericke, as of his predecessor William Gilbert, rested entirely on a comprehensive series of experiments, ingeniously thought out and keenly observed. The dramatic demonstrations of the pressure of air so overshadowed Guericke's work in electricity that less attention was paid to his electrical experiments by his contemporaries. For instance, one of the most moving demonstrations in the entire history of science was that of Guericke's "Magdeburg hemispheres" made before the assembled Diet of Ratisbon in 1654. In this, he applied two teams of eight horses each to pull apart two copper hemispheres fitted carefully together, from which the air had been exhausted by his vacuum pump. The teams strained but the hemispheres did not part. However,



OTTO De GUERICKE
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when the stop-cock leading to the sphere was opened, the air rushed in and the sphere parted.

Using the Guericke electric machine as a basis, the curator of instruments of the Royal Society, Francis Hauksbee, built a machine that extended the complexity of electrical display and he published his observations in the first decade of the 1700's. Hauksbee combined Guericke's two foremost contributions to science—his vacuum vessel and rotating sulphur ball—by integrating them into a glass sphere capable of being exhausted, yet mounted on trunions so that it might be rotated. A further improvement was to speed up the rotation of the ball by connecting it by a belt to a larger wheel turned by a crank. When the glass sphere was exhausted by an air-pump, and amber and wool were rubbed in the partial vacuum, a vivid luminosity was observed at the points of friction; remaining luminous as long as the revolving continued.

Beginning with the Guericke electrostatic machine, man's interest in electricity steadily increased. From this first sphere, the size of a child's head, others were built of increasing size and complexity until sparks 5 feet long were obtained. With these a more exact knowledge of the behavior of the electric charge and electrified bodies saw made possible.

# 100 Curricula in Electrical Engineering

R. G. KLOEFFLER
FELLOW AIEE

**During the past decade a great many changes have taken place in the engineering schools and still other changes are in progress today. The results of an analysis of the curricula of more than 100 colleges offering courses in electrical engineering are presented.**

THE PROFESSIONAL electrical engineer and the employer of college engineering graduates should be interested in the electrical engineering curriculum, its changes, and its trends in the engineering schools of today. Many changes have taken place in the past decade and others are in progress. In order to assess these changes, the author recently completed (1954) an analysis of the curricula of 100 colleges offering 4-year curriculums in electrical engineering and 6 colleges having 5-year curricula. This analysis made from recent college catalogues involved a check covering over 6,000 points. The results of this analysis are given in Fig. 1 and in detail in Table I. The reader may recall that the basis for college credit varies greatly among American colleges. A larger part of our institutions operate on a semester basis (approximately 15–16 weeks, excluding vacations), with others on a term basis which may vary from 6 to 12 weeks per term. Still other institutions may use some form of clock-hours of work (study, lecture, recitation, laboratory) for determining credit. The curricula of all 100 colleges have been converted to the semester-hour basis for comparison and analysis. The author does not claim infallibility in making such conversions for credit-hour basis or for interpretation of the content of courses as described in the various catalogues. However, the large number of schools involved (100) should make the errors largely compensating.

The factual data covered by his study are given in Table I. The subjects offered in electrical engineering curricula have been divided into appropriate groups for analysis. While the credit-hours per subject varied widely in exceptional cases, most colleges held closely to a common pattern. Any detailed analysis as to credit per subject or per group will be left to the reader.

A generalized picture of the current curriculum in electrical engineering is given in Fig. 1. This shows that the largest sector of the curriculum (over 25 per cent) consists of mathematics and the physical sciences (physics and chemistry). The second largest sector (25 per cent) consists of the subjects directly in the field of electrical engineering (basic and applied). The third sector covers basic and applied subjects in engineering (nonelectrical) and comprises 20 per cent of the total content of the curriculum. The fourth sector comprises subjects in English language, and the humanistic and social field (approximately 15 per cent of total). The last sector (14 per cent) includes electives and miscellaneous college requirements (military, physical education, seminars, orientation, etc.).

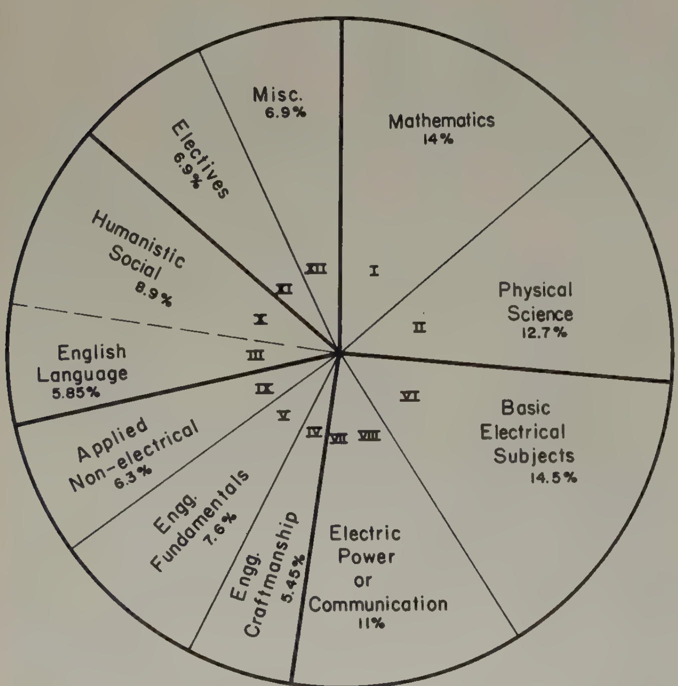


**Fig. 1. Curriculum chart for 100 engineering colleges**

## CURRICULUM CHANGES AND TRENDS

THE MAJOR change in the electrical engineering curriculum during the last 2 decades has been in the material offered in electrical engineering subjects. The new knowledge in electronics, semiconductors, and electromagnetic waves has been crowding for more and more space. With curriculum space already limited, some credit-hours have been made available by reducing the credit in d-c machinery, a-c machinery, and subjects related to the applications of electric power. Still more credit space has been made available by the introduction of options in communication and power wherein the student followed one option at the expense of other technical subject matter.

Full text of a special article recommended for publication by the AIEE Committee on Education.

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The electrical engineer who finished college 20 to 30 years ago will note a reduction in the credit devoted to drawing, shop practice, and kinematics, with corresponding increases in the credit-hours in mathematics, physical science, and the humanities. A recent trend is to add atomic or nuclear physics, more advanced mathematics, more electronics and wave theory, at the expense of the time devoted to electric power machinery.

## PROBLEMS IN CURRICULUM DESIGN

Since 1942 our electrical engineering faculties have been facing difficulties in curriculum adjustment from three directions. First, because of war or defense programs, many students have felt obliged to take advanced military training in order to remain in college. This training is usually accorded 8 to 12 semester credit-hours and this space must be found by a reduction in subject matter in some other area of training. Second, the new knowledge in electronics, semiconductors, electromagnetic waves, servomechanisms, etc., is basic, in part, to both the electric power and communication fields. Hence credit space in the order of 8 to 12 semester-hours must be provided. The third pressure for credit space has arisen in the field of humanities. This pressure has been especially troublesome in several engineering schools. Beginning one-quarter of a century ago, the engineering teaching profession through its Society for the Promotion of Engineering Education (now the American Society for Engineering Education) saw the need of more liberal education for engineering students and made recommendations in this direction. In 1944, this same organization adopted recommendations that 24 of the credit-hours offered in engineering curricula should be in the humanistic-social field. Throughout this period the engineering teacher and the practicing engineer have been in accord with the aims and recommendations for a liberalizing of the engineering curricula; in other words, the society and the engineering teachers have been eager to provide the broadest possible training. As a result, many changes were made in the addition of the humanistic-social content of engineering college curriculums. During World War II, several college administration leaders and college academic committees conceived the idea of reforming the professional schools by the introduction of more humanistic-social subjects in the professional curricula. This idea was implemented in several institutions by the requirement of new comprehensive courses, by common college, or through other plans. This new action was in line with general objectives which the engineering faculties had been advocating for years, but it came at a time when pressure from two other directions also was aimed at bringing in additional course material.

Adjustments in electrical engineering curricula to satisfy partially these three pressures to increase the curriculum content have been effected in several ways. One method has been to increase the number of credit-hours required for graduation. This step either places the engineering student at a further time disadvantage with respect to other students, or may result in a dilution of the value of the credit-hour.

A second method of subject adjustment has been to

**Table I. Analysis of 106 Electrical Engineering Curricula**

*Covers 4-Year Curricula for 100 Colleges Plus 5-Year Curricula for 6 Colleges; All Credit Reduced to Semester-Hour Basis*

| | Credit Range | Number of Colleges Requiring | Average Credit | Total for Group* |
|---|---|---|---|---|
| **I. Mathematics†** | | | | |
| College Algebra | 2–5.3 | 38 | 3.1 | |
| Trigonometry | 1.6–3.2 | 35 | 2.7 | |
| Analytical Geometry | 2.7–5.0 | 42 | 3.6 | |
| Calculus | 3–12 | 81 | 7.8 | |
| Differential Equations | 2–6 | 64 | 2.9 | |
| Integrated Mathematics | 1–24 | 70 | | 20.2 (23.5)* |
| **II. Physical Science** | | | | |
| Chemistry | 6–10 | 99 | 7.9 | |
| College Physics | 6–15 | 100 | 10.6 | 18.4 (24.4)* |
| **III. English Language** | | | | |
| Composition and Rhetoric | 2–12 | 100 | 5.94 | |
| Speech | 1–6 | 57 | 2.54 | |
| Technical Reports (Engg. English) | 0.7–4 | 42 | 2.57 | 8.5 (8.0)* |
| **IV. Engineering Craftsmanship** | | | | |
| Drawing | 2–7 | 100 | 3.8 | |
| Descriptive Geometry | 0.7–3 | 73 | 2.3 | |
| Shop (production methods) | 0.7–6 | 61 | 2.4 | |
| Mechanism (Kinematics) | 2–3.3 | 32 | 2.7 | 7.9 (9.3)* |
| **V. Engineering Fundamentals** | | | | |
| Statics and Dynamics (Applied Mechanics) | 2–9 | 100 | 5.3 | |
| Fluid Mechanics, Hydraulics | 1–5 | 64 | 3.0 | |
| Thermodynamics | 2.7–8 | 94 | 4.2 | 11.1 (13.9)* |
| **VI. Technical Electrical (common)** | | | | |
| Basic Electrical Engineering (electrodynamics) | 2–10 | 97 | 4.9 | |
| A-C Circuits | 1.5–10 | 99 | 5.6 | |
| Electrical Measurements | 1–6 | 62 | 2.75 | |
| Engineering Electronics (basic) | 2.7–9.5 | 96 | 4.6 | |
| D-C Machinery | 2–7 | 96 | 3.8 | 21.1 (21)* |
| **VII. Electric Power** | | | | |
| A-C Machinery | 3–13 | 99 | 8.1 | |
| Industrial Electronics and Control | 2–6 | 43 | 3.4 | |
| Transmission and Distribution Electric Power Systems | 2–6 | 57 | 3.3 | |
| Illumination | 1–4 | 21 | 2.4 | |
| Transients | 2–4 | 32 | 2.8 | |
| Design | 1.3–4.7 | 25 | 2.9 | |
| Miscellaneous | 1–21 | 49 | 4.6 | 16 (19.7)* |
| **VIII. Electronics and Communication** | | | | |
| A-C Machinery‡ | 3–10 | 37 | 6.35 | |
| Electronic Circuits | 2–10 | 59 | 5.3 | |
| Network Theory | 2–6 | 55 | 3.4 | |
| Communication (general) | 1.2–10 | 49 | 4.9 | |
| Electromagnetic Waves and Fields | 2–6 | 43 | 3.8 | |
| Servomechanisms | 2–6 | 8 | 3.0 | |
| Miscellaneous | | 21 | 4.0 | 12.5 (9.5)* |
| **IX. Applied (non-Electrical Engineering)** | | | | |
| Heat Power | 1–8 | 57 | 3.5 | |
| Strength of Materials (mechanics of materials) | 2–9 | 92 | 3.9 | |
| Metallurgy | 1.3–4 | 15 | 2.3 | |
| Surveying | 0.8–5 | 49 | 2.4 | |
| Economics (applied) | 1.3–7 | 33 | 3.0 | 9.1 (8.7)* |
| **X. Humanistic-Social** | | | | |
| Economics (basic) | 2–6 | 81 | 3.9 | |
| History and Civilization | 2–14 | 37 | 5.7 | |
| Literature | 1–6 | 31 | 4.0 | |
| Miscellaneous | 1.2–24 | 68 | 9.4 | 12.9 (19.5)* |
| **XI. Electives** | | | | |
| Free | 2–20 | 35 | 7.3 (7.2)* | |
| Technical | 3–24 | 52 | 8.8 (12)* | |
| Nontechnical | 2–25 | 37 | 8.1 (8)* | 10 (22)* |
| **XII. Physical Education** | 2–4 semesters | 75 | | |
| **XIII. Military Science** | | 62 | | |
| **XIV. Options** | | | | |
| None | | 55 | | |
| Power | | 41 | | |
| Communication | | 41 | | |
| Other | | 13 | | |
| **XV. Credit for graduation** | | | 145—4-year (177—5-year) | |

* Figures in parenthesis are for 5-year curriculum.

† Some colleges require algebra and trigonometry as an entrance requirement; in others these courses and analytical geometry and calculus are given in integrated courses in mathematics.

‡ Credit-hours of A-C Machinery required in Electronics and Communication option.

replace the hours originally specified as electives by credits from the fields of pressure. The third method of adjustment has been to employ options wherein the student becomes more specialized and follows the field of electric power or communication only. This latter method is illustrated in group XIV on options of Table I. This table shows that 41 colleges offer options in (1) electric power, and (2) communication or electronics. Many of the 51 colleges which do not list options accomplish the effect of options by dropping some subjects and replacing the released credit by elective credit which permits the student to obtain the same result as in those cases where options are listed.

In surveying the problems in curriculum design, the reader is likely to conclude that the obvious answer is for engineering schools to change to a 5- or 6-year curriculum as other professional schools have done. Let us look at this idea further.

### 5-YEAR CURRICULA IN ELECTRICAL ENGINEERING

A small number of engineering schools have adopted a 5-year curriculum in electrical engineering, presumably because of the pressures suggested in the preceding paragraphs. Six colleges in this class were included in this survey and the credit-hours given in the various groups of subjects are shown in parentheses in the table. A study of this table shows that the additional credit-hours made available by the fifth year have permitted increases as follows.

| Subject | Average Credit-Hour Increase |
|---|---|
| Mathematics | 3.3 |
| Physical science | 6.0 |
| Engineering craftsmanship | 1.4 |
| Engineering fundamentals | 2.8 |
| Humanistic-social | 6.6 |
| Electives | 12.0 |

The major increases are in physical science, humanistic-social, and electives which will bring relief to all of the pressures discussed earlier. Thus the 5-year curriculum in electrical engineering has a definite advantage in respect to subject matter though it does not solve all curriculum problems.

An alternative plan is the 5-year 2-degree program. One form of this plan was introduced by the author in 1940. Arrangements were made whereby an electrical engineering student could obtain a degree of bachelor of science in business administration by a fifth year of work beyond the 4-year electrical engineering course. An increasing number of students (over 12 per cent of class) have availed themselves of this program. This alternative gives the student desirable additional training to qualify him for commercial and administrative work and also includes additional courses in the humanistic-social field. However, this program is not the final answer to all problems. A second 2-degree program which requires 5 years has been used widely for a long time. It uses the fifth year for a master's degree and its advantages are well recognized. However, this program also is not an answer to all curriculum problems.

### SOLUTION TO THE CURRICULUM PROBLEM?

The professional electrical engineers and the employers of electrical engineers have influenced the engineering curriculum for many years and they should continue to assist in the solution of the current problems. In approaching this problem, it is well to recognize the three following points:

1. There is an essential core of mathematics, physical science, and engineering technology which should be included in the training of every engineer. A minimum of 4 years is needed for the average engineer to acquire this training.
2. There is certain specialized training needed by an engineering student to (*a*) suit the characteristics of the individual, and (*b*) to fit him for the role he will play in his profession. This implies subject matter in business administration, special technical subject matter, research techniques, teaching methods, etc.
3. The need for humanistic-social subjects, development of appreciation for music, art, and literature, and additional work in written and oral communication. These are needed if the engineer is to fill his proper place as a citizen and leader in his profession.

In regard to point 3, the author wishes to make some personal observations which arise from 35 years in teaching and counseling with electrical engineering students. The typical engineering college student differs from many other students in certain respects. He has chosen this profession because his major interest lies in mathematics, science, machines, and material things. He is very intent in his thinking and is eager to get on with his training. To him technological things are meat and potatoes and as a student he cares little for subjects which he considers to be of the salad and vegetable type. Hence if the undergraduate curriculum contains several credit-hours of subjects in history, literature, appreciation courses, civilization, etc., the engineering student is irked by the requirement and the purpose for which these courses were included is largely lost.

Experience shows that when the engineering student is graduated and becomes exposed to the problems of the working world, he soon becomes conscious of his inherent deficiencies as a public speaker and as a writer of engineering reports. He also realizes that he has missed something in college which his co-worker who studied arts and sciences has acquired. At this point the young engineer is conditioned to the need of certain additional training needed to fit him for the fullest opportunity as a citizen. This is the time when the training covered by point 3 is needed. But the young man now has no easy access to college or stimulation to acquire his needs.

The author believes that it is the duty of engineering colleges to provide a postgraduation follow-up among its younger graduates and to offer through correspondence suggestions and home study courses in nontechnical fields of the kind suggested in point 3. The older professional engineer and the employer likewise should encourage and assist in this needed program to complete the ideal curriculum for the training of the engineer.

# Distribution of Engineering Graduates and Demand for Engineers—1953

ENGINEERS JOINT COUNCIL COMMITTEE REPORT

THIS REPORT provides the results and analyses of two surveys conducted by Engineers Joint Council (EJC). These are the survey of engineering schools having accredited curricula to determine the number of graduates in the year ending June 1953 and their probable distribution, and the EJC survey of industry to determine the demand for new engineering graduates as well as more experienced engineers.

**The supply of and demand for engineering graduates was the subject of two surveys conducted by a Special Surveys Committee of Engineers Joint Council during 1953: a survey of engineering schools to determine the number of graduates and their probable distribution, and a survey of industry to determine the demand for engineers.**

These surveys were conducted by the EJC Special Surveys Committee with the co-operation of the staff of the Engineering Manpower Commission (EMC) of EJC in cordance with its stated function of maintaining a continuing surveillance of the national scene with respect to engineering manpower so as to provide a clearinghouse of information for, and a channel of communication between the profession, industry, government, and others on this subject.

## DISTRIBUTION OF SUPPLY OF ENGINEERING GRADUATES—1953

*The Reporting Sample.* The Survey of the Distribution of Supply was made during the spring of 1953 by forwarding a questionnaire to the dean of engineering at each school having an accredited Engineers' Council for Professional Development (ECPD) curricula. The survey was kept open until September 15, 1953, to allow for the receipt of a maximum number of replies. By that time replies had been received from all schools having ECPD accredited curricula except four. The report as presented is based upon the actual returns received. An analysis of the previous data on the graduates of the schools not reporting indicates that the report as presented contains about 95 per cent of the over-all picture of accredited school graduates and their distribution.

Following is a compiled questionnaire containing the total results received from all the schools reporting. EMC elaborating comment on the various factors involved follows the compiled report.

*Engineers Joint Council*

Accredited Schools
1953 Engineering Education Survey

In order to provide information concerning the probable distribution of supply of newly graduated engineers between the military services, industry, and engineering education, and information about the capacity of our schools of engineering, we would appreciate your help to the extent of furnishing the data requested below. A copy of the report will be furnished you upon completion of the survey.

| | *Number* | *Per Cent* |
|---|---|---|
| 1. How many first engineering degrees will you confer during the academic year beginning July 1, | | |

**Table I. Returns by Size of Company and Industry**

| Number of Employees: Industry | SIC Code | 250 | 250–499 | 500–999 | 1,000–2,499 | 2,500–4,999 | 5,000–9,999 | 10,000–24,999 | 25,000 and Over | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| Total industry | | 33 | 34 | 54 | 75 | 50 | 41 | 36 | 30 | 353 |
| Chemicals and allied products | 28 | 1 | 3 | 2 | 4 | 4 | 4 | 4 | 2 | 24 |
| Machinery (except electric) | 35 | 6 | 11 | 13 | 13 | 5 | 7 | 2 | 1 | 58 |
| Electric machinery, equipment, and supplies | 36 | 2 | 1 | 6 | 7 | 7 | 4 | 2 | 5 | 34 |
| Transportation equipment | 37 | 5 | 3 | 3 | 1 | 1 | 3 | 3 | 7 | 26 |
| Professional and scientific instruments | 38 | 2 | 5 | 2 | 4 | 2 | | 2 | | 17 |
| Railroads | 40 | 1 | 1 | | | 2 | | 2 | 8 | 14 |
| Misc. services: consulting firms, research, development, etc. | 89 | 5 | 3 | 3 | | | 1 | | | 12 |
| Public utilities (including operating telephone companies) | 48–49 | | | 7 | 24 | 13 | 6 | 2 | 2 | 54 |
| Metal mining | 10 | | | | | | | | | |
| Primary metal industries | 33 | 5 | 6 | 8 | 6 | 5 | 5 | 6 | 1 | 42 |
| Fabricated metal products | 34 | | | | | | | | | |
| Crude petroleum and natural gas | 13 | 1 | | 2 | 4 | 4 | 2 | 6 | 1 | 20 |
| Products of petroleum and coal | 29 | | | | | | | | | |
| Other industries | 11, 14, 15, 19, 22, 24, 26, 20, 30, 31, 32, 52 | 5 | 1 | 8 | 12 | 7 | 9 | 7 | 3 | 52 |

Personnel of EJC Special Surveys Committee: M. M. Boring (*Chairman*), American Society for Engineering Education; G. A. Hathaway, American Society of Civil Engineers; M. D. Cooper, American Institute of Mining and Metallurgical Engineers; H. N. Muller, Jr., The American Society of Mechanical Engineers; D. S. Bridgman, AIEE; W. N. Landers, The Society of Naval Architects and Marine Engineers; N. A. Shepard, American Institute of Chemical Engineers; H. C. R. Carlson, National Society of Professional Engineers.

| | Number | Per Cent |
|---|---|---|
| 1952, and ending June 30, 1953? | 20,607 | |

2. How many of the recipients of these first degrees will receive commissions in the Armed Forces as a result of ROTC training? 4,928 — 24
If available please give a breakdown of these commissions: Regular Army, 149; Regular Navy, 187; Reg. Air Force, 110; Reg. Marines, 18; Army Reserve, 1,825; Naval Reserve, 245; Air Reserve, 153; Marine Corps Res., 12.
3. How many other recipients of these first degrees are enlisted members of the Armed Forces reserves or national guard? 407 — 2
4. How many other recipients of these first degrees will become draft eligible upon graduation? 5,102 — 25
*5. How many recipients of these first degrees are enrolled in or seriously planning to continue full-time graduate studies? 1,175 — 5 3/4
6. What is your total enrollment in engineering courses in the lower classes and how many of each of these are enrolled in ROTC units?

| | *Total engineering enrollment* | *No. of engineers in ROTC* |
|---|---|---|
| 1956 (*a*) 1st year (freshmen) | 37,581 | 21,290 |
| 1955 (*b*) 2d year (sophomores) | 23,522 | 13,032 |
| 1954 (*c*) 3d year (juniors) | 20,751 | 6,508 |
| 1953 (*d*) 4th year (seniors) | 2,902 | 463 |

7. Was your freshman mortality at the end of the first term higher or lower than usual? .... If so, how much? .... What factors have been responsible?
*8. How many engineering graduates of the class of 1953 will you require as full-time staff additions? (Graduate Assistants, etc.) 440
9. How many other engineering graduates will you require as new full-time staff members? 855
10. What is your present total engineering undergraduate enrollment? (Total of questions 1 and 6) 105,365
11. Can you accommodate additional engineering students without major changes in your existing program? yes If so, how many? 31,864
12. Based on present indications how many entering engineering freshmen do you anticipate in the fall of 1953? 43,801

* In cases of conflict between questions 5 and 8 the individual should be reflected wholly in the activity which will predominate.

*EMC Comment.* Regarding question 2, it is interesting and important to note that the percentage of engineering graduates commissioned in the Reserve Officers Training Corps (ROTC) continues to rise. In 1951, 11 per cent were commissioned. In 1952, 16$^1/_2$ per cent were commissioned; this year it is 24 per cent. The data provided in question 7 indicate that in 1954, 29$^1/_2$ per cent will be commissioned. It should be noted, however, that Department of Defense adjustments of ROTC plans probably will result in fewer commissions than presently are scheduled.

Also regarding question 2, the breakdown of commissions awarded does not equal the total figure presented for ROTC commissions because many schools did not report a breakdown. They provided only the over-all figure.

The answer to question 3 is probably considerably below the actual number because many of the schools reported a lack of knowledge regarding this aspect of their students activities or obligations. The same can be said of question 4.

In question 6 the class listed as 1953 fourth-year seniors refers to the fourth-year students in 5-year curricula.

The replies to question 7 are summarized as follows:

85 schools answered that their freshmen mortality was about the same as experienced in recent years.

23 schools reported a lower freshmen mortality.

19 schools reported a higher freshmen mortality.

**Table II. Comparison Between Survey Sample for Each Industry and the Estimated Total Size of That Industry**

| Industry | SIC Code | Average Annual Total Employment* | Estimated Engineering Employment† | Number of Returns | Total Employees | Total Engineering Graduates Employed |
|---|---|---|---|---|---|---|
| Total industry and government | | 48,650,000 | 440,000 | 376 | 4,151,210 | 125,086 |
| Total industry | | 42,000,000 | 350,000 | 353 | 4,038,386 | 107,937 |
| Chemicals and allied products | 28 | 761,000 | 27,000 | 24 | 231,713 | 11,314 |
| Machinery (except electric) | 35 | 1,719,200 | 35,000 | 58 | 147,231 | 4,144 |
| Electric machinery, equipment, and supplies | 36 | 1,198,000 | 30,000 | 34 | 623,404 | 29,860 |
| Transportation equipment | 37 | 1,951,700 | 35,000 | 26 | 887,679 | 19,734 |
| Professional and scientific instruments | 38 | 330,300 | 6,000 | 17 | 57,746 | 4,151 |
| Railroads | 40 | 1,357,700 | 7,500 | 14 | 441,292 | 1,817 |
| Misc. services: consulting firms, research, development, etc. | 89 | | 25,000 | 12 | 11,506 | 2,690 |
| Public utilities (including operating telephone companies) | 48–49 | 1,305,000 | 45,000 | 54 | 785,317 | 14,319 |
| Metal mining | 10 | | | | | |
| Primary metal industries | 33 | 3,099,000 | 23,500 | 42 | 256,402 | 5,039 |
| Fabricated metal products | 34 | | | | | |
| Crude petroleum and natural gas | 13 | 383,000 | 26,500 | 20 | 166,045 | 8,311 |
| Products of petroleum and coal | 29 | | | | | |
| Other industry | 11, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 52 | 7,356,700 | 60,000 | 52 | 430,051 | 6,558 |
| Total government | 90 | 6,650,000 | 90,000 | 23 | 112,824 | 17,149 |

* Source: Employment and payrolls—April 1953. A monthly statistical report of the Bureau of Labor Statistics, U. S. Department of Labor.
† Source: Rough estimates by Bureau of Labor Statistics and EMC of EJC.

The comments explaining increased and decreased freshmen mortality indicated that those schools which utilized the opportunity presented by greater interest in engineering to exercise a higher degree of selectivity, experienced a lower freshmen mortality. Those schools that did not or were unable to translate increased interest into greater selectivity, experienced a higher mortality. In any case, the amount of change in either direction was not sufficient to indicate a trend.

It is perhaps interesting to note that in answer to question 12, the deans of engineering from the respondent schools estimated a freshmen class in 1953 numbering 43,801. The actual figure, for ECPD accredited curricula, recently obtained from the U.S. Office of Education, is 52,482.

In view of the various programs being carried on to interest additional numbers of qualified young people in engineering careers, and the statements of certain government agencies concerning a lack of space for returning Korean veterans, it was felt necessary to make some determination of the ability of the engineering schools to absorb increased enrollments. Although there was no attempt to break the answers down regionally or into types of curricula, the result obtained in question 11 indicates an over-all ability on the part of the engineering schools to absorb a substantially greater enrollment without significant changes in their existing staffs or programs.

### THE NEED FOR ENGINEERING GRADUATES IN 1953‡

*Summary.* Some 376 industrial firms and government agencies out of some 2,100 to whom questionnaires were sent, provided useful information to the EJC Survey Committee on their needs for engineers. These 376 firms and agencies currently employ almost 125,086 engineers, or nearly 26 per cent of the estimated 475,000 engineers in the United States.

If these organizations are representative of their respective industries in their need for new graduates in 1953 the total need for new graduates in 1953 was of about the same order of magnitude as 1952 although there were signs of a softening in demand. It can be said that the need was

‡ Report on Survey by the EJC Engineering Manpower Commission.

**Table III. Breakdown by Industry of Actual Engineering Employment in 1952, Expected Engineering Employment in 1953, and Required Engineering Employment in 1953**

| Industry | Actual Engineering Employment, 1952 | Expected Engineering Employment, 1953 | Required Engineering Employment, 1953 |
|---|---|---|---|
| Total industry and government | 116,653 | 131,778 | 137,885 |
| Total industry | 99,204 | 114,708 | 120,071 |
| Chemicals and allied products | 10,306 | 12,229 | 12,986 |
| Machinery (except electric) | 3,848 | 4,661 | 4,893 |
| Electric machinery, equipment, and supplies | 26,844 | 31,505 | 33,424 |
| Transportation equipment | 17,578 | 21,030 | 22,218 |
| Professional and scientific instruments | 3,456 | 4,842 | 5,007 |
| Railroads | 1,782 | 1,883 | 1,917 |
| Misc. services: consulting firms, research, development, etc. | 2,495 | 2,842 | 2,902 |
| Public utilities (including operating telephone companies) | 14,133 | 14,628 | 15,005 |
| Metal mining | | | |
| Primary metal industries | 4,915 | 5,137 | 5,306 |
| Fabricated metal products | | | |
| Crude petroleum and natural gas | | | |
| Products of petroleum and coal | 7,685 | 8,856 | 9,108 |
| Other industry | 6,162 | 7,095 | 7,305 |
| Total government | 17,449 | 17,070 | 17,814 |

**Table IV. Breakdown by Industry of Actual Engineering Employment, 1952**

| Industry | SIC Code | Number of Returns | Total Engineers in Employ 1/1/52 | Total Losses All Classes | Employment 1952 B.S. | Employment 1952 M.S. | Employment 1952 Ph.D. | Total | From Earlier Classes | Returns From Military Leave | Total Net Accessions | B.S. Hires as Per Cent of Total Engrs. Employed | B.S., M.S., Ph.D. Hires as Per Cent of Total Engrs. Employed | Hires Experienced Engrs. as Per Cent of Total Engrs. Employed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total of industry and government | | 376 | 116,653 | 10,326 | 10,409 | 1,044 | 288 | 11,741 | 5,616 | 977 | 7,031 | 8.9 | 10 | 4.8 |
| Total industry | | 353 | 99,204 | 8,184 | 9,678 | 1,011 | 287 | 10,962 | 4,760 | 756 | 7,552 | 9.7 | 11 | 4.9 |
| Chemicals and allied products | 28 | 24 | 10,306 | 725 | 980 | 107 | 49 | 1,136 | 496 | 101 | 907 | 9.5 | 11 | 4.8 |
| Machinery (except electric) | 35 | 58 | 3,848 | 369 | 407 | 11 | 2 | 420 | 191 | 54 | 242 | 10.6 | 10.9 | 4.9 |
| Electric machinery, equipment, and supplies | 36 | 34 | 26,844 | 2,043 | 2,690 | 441 | 85 | 3,216 | 1,289 | 129 | 2,462 | 10.4 | 11.9 | 4.8 |
| Transportation equipment | 37 | 26 | 17,578 | 2,052 | 2,702 | 184 | 55 | 2,941 | 1,209 | 58 | 2,098 | 15.3 | 16.5 | 6.8 |
| Professional and scientific instruments | 38 | 17 | 3,456 | 403 | 594 | 57 | 5 | 656 | 411 | 31 | 664 | 17.1 | 19 | 11.9 |
| Railroads | 40 | 14 | 1,782 | 121 | 104 | 1 | | 105 | 40 | 11 | 24 | 5.8 | 5.8 | 2.3 |
| Misc. services: consulting firms, research and development | 89 | 12 | 2,495 | 253 | 187 | 63 | 19 | 269 | 167 | 12 | 183 | 7.5 | 10.7 | 6.7 |
| Public utilities and operating telephone companies | 48, 49 | 54 | 14,133 | 698 | 446 | 5 | | 451 | 219 | 214 | 28 | 3.1 | 3.1 | 1.5 |
| Metal mining; Primary metal industry; Fabricated products | 10, 33, 34 | 42 | 4,915 | 418 | 353 | 8 | 3 | 364 | 148 | 30 | 94 | 7.2 | 7.4 | 3 |
| Crude petroleum and natural gas; Products of petroleum and coal | 13, 29 | 20 | 7,685 | 536 | 746 | 90 | 39 | 875 | 220 | 67 | 559 | 9.8 | 11.4 | 2.8 |
| Other industries | 11, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 52 | 52 | 6,162 | 566 | 469 | 44 | 30 | 543 | 370 | 49 | 347 | 7.6 | 8.8 | 6 |
| Government | 90 | 23 | 17,449 | 2,142 | 731 | 33 | 1 | 765 | 856 | 221 | −521 | 4.2 | 4.4 | 4.9 |

## Table V. Breakdown by Industry of Expected Engineering Employment, 1953

| Industry | SIC Code | Number of Returns | Total Engineers in Employ 1/1/53 | Total Losses, All Classes | Employment 1953 B.S. | Employment 1953 M.S. | Employment 1953 Ph.D. | Total | From Earlier Classes | Returns From Military Leave | Total Net Accessions | Total Engineering Graduates in Employ 12/31/53 | B.S. Hires as Per Cent of Total Engrs. Employed | B.S., M.S., Ph.D. Hires as Per Cent of Total Engrs. Employed | Hires Experienced Engrs. as Per Cent of Total Engrs. Employed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total of industry and government | | 376 | 125,086 | 10,663 | 9,774 | 1,124 | 350 | 11,248 | 4,694 | 1,413 | 5,279 | 131,778 | 3.7 | 9.0 | 3.7 |
| Total industry | | 353 | 107,937 | 8,418 | 8,805 | 1,091 | 341 | 10,237 | 3,902 | 1,050 | 5,721 | 114,708 | 8.2 | 9.0 | 3.6 |
| Chemicals and allied products | 28 | 24 | 11,314 | 567 | 851 | 108 | 59 | 1,018 | 309 | 155 | 760 | 12,229 | 7.5 | 9.0 | 2.2 |
| Machinery (except electric) | 35 | 58 | 4,144 | 344 | 478 | 19 | 2 | 499 | 298 | 64 | 453 | 4,661 | 11.5 | 12 | 7.1 |
| Electric machinery, equipment, and supplies | 36 | 34 | 29,860 | 2,477 | 2,279 | 473 | 97 | 2,849 | 1,042 | 231 | 1,414 | 31,505 | 7.6 | 9.5 | 3.5 |
| Transportation equipment | 37 | 26 | 19,734 | 2,489 | 2,344 | 233 | 58 | 2,635 | 1,068 | 82 | 1,214 | 21,030 | 11.8 | 13.3 | 5.4 |
| Professional and scientific instruments | 38 | 17 | 4,151 | 431 | 679 | 59 | 13 | 751 | 331 | 40 | 651 | 4,842 | 16.2 | 18 | 8 |
| Railroads | 40 | 14 | 1,817 | 58 | 97 | 1 | | 98 | 14 | 12 | 54 | 1,883 | 5.3 | 5.3 | 0.8 |
| Misc. services: consulting firms, research and development | 89 | 12 | 2,690 | 212 | 189 | 60 | 34 | 283 | 66 | 15 | 137 | 2,842 | 7.0 | 10.5 | 2.4 |
| Public utilities and operating telephone companies | 48, 49 | 54 | 14,319 | 553 | 470 | 2 | 1 | 473 | 157 | 232 | 77 | 14,628 | 3.8 | 3.9 | 1.9 |
| Metal mining<br>Primary metal industries<br>Fabricated metal products | 10<br>33<br>34 | 42 | 5,039 | 359 | 337 | 5 | 4 | 346 | 80 | 31 | 67 | 5,137 | 6.2 | 6.4 | 1.5 |
| Crude petroleum and natural gas<br>Products of petroleum and coal | 13<br>29 | 20 | 8,311 | 506 | 648 | 88 | 46 | 782 | 175 | 94 | 451 | 8,856 | 7.7 | 9.4 | 2.1 |
| Other industries | 11, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 52 | 52 | 6,558 | 422 | 433 | 43 | 27 | 503 | 362 | 94 | 443 | 7,095 | 6.6 | 7.5 | 5.5 |
| Government | 90 | 23 | 17,149 | 2,245 | 969 | 33 | 9 | 1,011 | 792 | 363 | −442 | 17,070 | 5.6 | 5.9 | 4.6 |

## Table VI. Breakdown by Industry of Required Engineering Employment, 1953

| Industry | SIC Code | Number of Returns | Total Engineers in Employ 1/1/53 | Employment 1953 B.S. | Employment 1953 M.S. | Employment 1953 Ph.D. | Total | From Earlier Classes | Total Net Accessions | B.S. Hires as Per Cent of Total Engrs. Employed | B.S., M.S., Ph.D. Hires as Per Cent of Total Engrs. Employed | Hires Experienced Engrs. as Per Cent of Total Engrs. Employed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total of industry and government | | 376 | 125,086 | 13,707 | 1,789 | 522 | 16,018 | 6,031 | 11,386 | 10.9 | 12.8 | 4.8 |
| Total industry | | 353 | 107,937 | 12,088 | 1,707 | 513 | 14,308 | 5,001 | 10,891 | 11.2 | 13.3 | 4.6 |
| Chemicals and allied products | 28 | 24 | 11,314 | 1,134 | 197 | 122 | 1,453 | 420 | 1,306 | 10 | 12.8 | 3.7 |
| Machinery (except electric) | 35 | 58 | 4,144 | 615 | 21 | 2 | 638 | 329 | 623 | 14.8 | 15.4 | 7.9 |
| Electric machinery equipment and supplies | 36 | 34 | 29,860 | 3,619 | 856 | 159 | 4,634 | 1,398 | 3,555 | 12.1 | 15.5 | 4.7 |
| Transportation equipment | 37 | 26 | 19,734 | 2,973 | 303 | 85 | 3,361 | 1,542 | 2,414 | 15 | 17 | 7.8 |
| Professional and scientific instruments | 38 | 17 | 4,151 | 726 | 69 | 14 | 809 | 405 | 783 | 17.5 | 19.4 | 9.7 |
| Railroads | 40 | 14 | 1,817 | 133 | 2 | | 135 | 16 | 93 | 7.3 | 7.4 | 0.9 |
| Misc. services: consulting firms, research and development | 89 | 12 | 2,690 | 195 | 60 | 34 | 289 | 67 | 144 | 7.3 | 10.8 | 2.5 |
| Public utilities and operating telephone companies | 48, 49 | 54 | 14,319 | 836 | 4 | 1 | 841 | 165 | 453 | 5.8 | 5.8 | 1.1 |
| Metal mining<br>Primary metal industries<br>Fabricated metal products | 10<br>33<br>34 | 42 | 5,039 | 495 | 8 | 7 | 510 | 86 | 237 | 9.2 | 9.5 | 1.6 |
| Crude petroleum and natural gas<br>Products of petroleum and coal | 13<br>29 | 20 | 8,311 | 792 | 141 | 62 | 995 | 198 | 687 | 9.5 | 9.9 | 2.4 |
| Other industries | 11, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 52 | 52 | 6,558 | 570 | 46 | 27 | 643 | 375 | 596 | 8.7 | 9.8 | 5.3 |
| Government | 90 | 23 | 17,149 | 1,619 | 82 | 9 | 1,710 | 1,030 | 495 | 9.4 | 10 | 6 |

substantially greater than the number of graduates (21,612). It should be mentioned, however, that there is reason to believe that most of the reporting organizations, by the fact of the report, may have somewhat greater need for engineers than is typical in their respective industries, although some companies reported no need for additional personnel and other companies reported a lesser need than in 1952.

*The Reporting Sample.* The 376 firms and agencies which reported by October 15, 1953, included 353 industrial organizations and 23 government agencies. The industrial firms employed 107,937 engineers out of an estimated 350,000; the government agencies employed 17,149 out of an estimated 90,000 engineers employed in federal, state, and local government agencies. In addition to the needs of these companies, EJC in its survey of the engineering schools found that the reporting institutions had a need for a total of 440 engineering graduates of the class of 1953 as full-time additions to their staff (graduate assistants). Also, the reporting schools had a total need of 855 other engineering graduates for full-time staff duties.

As returns to the Demand Survey were received from the respondent companies they were classified carefully as to company size and industrial classification. Table I presents an analysis of the survey sample by size of company. An attempt was made in this survey to obtain information from a greater number of smaller companies than had participated in previous surveys. We feel that to an important extent this was successful.

**Table VII. Turnover of Engineers, 1952**

| Industry | SIC Code | Number of Returns | Total Engineers in Employ 1/1/52 | Total Losses All Classes | Losses as Per Cent of Total Engrs. in Employ 1/1/52 | Total Net Accessions | Net Accessions as Per Cent of Total Engrs. in Employ 1/1/52 |
|---|---|---|---|---|---|---|---|
| Total of industry and government | | 376 | 116,653 | 10,326 | 8.6 | 7,031 | 6.0 |
| Total industry | | 353 | 99,204 | 8,184 | 8.1 | 7,552 | 7.5 |
| Chemicals and allied products | 28 | 24 | 10,306 | 725 | 7.1 | 907 | 8.8 |
| Machinery (except electric) | 35 | 58 | 3,848 | 369 | 9.6 | 242 | 6.3 |
| Electric machinery equipment and supplies | 36 | 34 | 26,844 | 2,043 | 7.5 | 2,462 | 9.2 |
| Transportation equipment | 37 | 26 | 17,578 | 2,052 | 11.5 | 2,098 | 11.9 |
| Professional and scientific instruments | 38 | 17 | 3,456 | 403 | 12.1 | 664 | 19.2 |
| Railroads | 40 | 14 | 1,782 | 121 | 6.8 | 24 | 1.3 |
| Misc. services: consulting firms, research and development | 89 | 12 | 2,495 | 253 | 10.1 | 183 | 7.3 |
| Public utilities, including operating telephone companies | 48, 49 | 54 | 14,133 | 698 | 4.9 | −28 | −1.9 |
| Metal mining; Primary metal industries; Fabricated metal products | 10, 33, 34 | 42 | 4,915 | 418 | 8.5 | 94 | 1.9 |
| Crude petroleum and natural gas; Products of petroleum and coal | 13, 29 | 20 | 7,685 | 536 | 7 | 559 | 7.3 |
| Other industries | 11, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 52 | 52 | 6,162 | 566 | 9.1 | 347 | 5.6 |
| Government | 90 | 23 | 17,449 | 2,142 | 12.5 | −521 | −5.2 |

**Table VIII. Turnover of Engineers, 1953**

| Industry | SIC Code | Number of Returns | Total Engineers in Employ 1/1/53 | Total Losses All Classes | Losses as Per Cent of Total Engrs. in Employ 1/1/53 | Total Net Accessions | Net Accessions as Per Cent of Total Engrs. in Employ 1/1/53 |
|---|---|---|---|---|---|---|---|
| Total of industry and government | | 376 | 125,086 | 10,663 | 8.5 | 5,279 | 4.2 |
| Total industry | | 353 | 107,937 | 8,418 | 7.8 | 5,721 | 5.4 |
| Chemicals and allied products | 28 | 24 | 11,314 | 567 | 5 | 760 | 6.7 |
| Machinery (except electric) | 35 | 58 | 4,144 | 344 | 8.3 | 453 | 11.0 |
| Elec. machinery equipment and supplies | 36 | 34 | 29,860 | 2,477 | 8.2 | 1,414 | 4.7 |
| Transportation equipment | 37 | 26 | 19,734 | 2,489 | 12.5 | 1,214 | 6.1 |
| Professional and scientific instruments | 38 | 17 | 4,151 | 431 | 10.4 | 651 | 15.7 |
| Railroads | 40 | 14 | 1,817 | 58 | 3.2 | 54 | 3.0 |
| Misc. services: consulting firms, research and development | 89 | 12 | 2,690 | 212 | 8 | 137 | 5.2 |
| Public utilities, including operating telephone companies | 48, 49 | 54 | 14,319 | 553 | 3.8 | 77 | 0.5 |
| Metal mining; Primary metal industries; Fabricated metal products | 10, 33, 34 | 42 | 5,039 | 359 | 7.1 | 67 | 1.3 |
| Crude petroleum and natural gas; Products of petroleum and coal | 13, 29 | 20 | 8,311 | 506 | 6.1 | 451 | 5.4 |
| Other industries | 11, 14, 15, 19, 20, 22, 24, 26, 30, 31, 32, 52 | 52 | 6,558 | 422 | 6.4 | 443 | 6.8 |
| Government | 90 | 23 | 17,149 | 2,245 | 13 | −442 | −2.5 |

Companies were classified by industry in accordance with the "Standard Industrial Classification Manual" published by the Bureau of the Budget in the Executive Office of the President. The Standard Industrial Classification (SIC) Code derived from this publication is intended primarily as an aid in securing uniformity and comparability in the presentation of statistical data collected by various activities. In this way greater correlation of studies which are separated by time or activity is made possible.

However, the data as presented in accordance with the SIC Code in this report are subject to two important limitations that should be kept in mind. First, the Standard Industrial Classification System, while it is very useful, can be somewhat misleading because many companies having important activities in several categories must be classified, of necessity, in only one. To attempt a breakdown for each company would be beyond the scope of this survey and probably beyond the capacity and willingness of many companies to provide the necessary detailed information.

Second, accurate projection of a sample such as is used in this survey is virtually impossible. This results from a lack of sufficiently accurate information on the total number of engineers in the country, and the number of engineers employed in government and in the various kinds of industry. In view of the many variables involved, therefore, only summary conclusions such as are presented earlier in this report can be provided with any reasonable expectancy of accuracy.

# EJC and the Engineering Profession

T. A. MARSHALL, JR.

**The unity of the engineering profession is a topic of great interest to engineers. In the belief that the Engineers Joint Council can become the unity organization that the profession is seeking, the author shows how the Council is organized, and discusses what it is doing now and how it is developing.**

OVER THE YEARS, the engineer has become the symbol for precise work and accuracy. This has come about because of his objectivity and his search for facts upon which to base his contributions to research, development, design, production, and distribution in improving America's living standard and way of life.

However, it is surprising to note the lack of accuracy, or clear delineation, of the elements of a subject of extreme importance and interest to the entire engineering profession. It is a subject that is discussed frequently at meetings of engineers, and by various groups of engineers in their day to day contacts; a subject that has been termed "the unity of the engineering profession."

## DEFINITION OF "UNITY"

UNITY has several meanings. It is subject to different interpretations by different individuals. Unity can mean, for example, "absence of diversity." It can mean "uniformity"; or "a unity of sentiment"; or "unification." It can mean "continuity without deviation of change." These are some of the accepted definitions of unity.

Such unity is not the kind that the engineering profession wants, or needs, or means, or can achieve when engineers speak of unity. In dealing with this problem, as in dealing with any other problem, there must be fundamental agreement regarding its basic elements.

There would seem to be two essential elements of engineering unity. First, the unity organization must be formed, not to achieve unity in the afore-mentioned senses, but to achieve unity in the sense of solidarity. Solidarity connotes a community of interests, objectives, standards, and responsibilities that will permit the profession, as a group, to express its opinions, manifest its strength, or exert its influence as a unit in specific areas. This does not require "uniformity" or "absence of diversity" or "unification," or "continuity without deviation or change."

An excellent example may be found in the American Medical Association (AMA). This organization frequently is alluded to in discussions on engineering unity. Many doctors disagree with some of the policies and actions of AMA. Some doctors are not even members of AMA. However, the association does express the opinion of the medical profession as a group without the unanimity expressed in some of the definitions of unity previously mentioned.

Second, there must be—and this may be considered by some as heresy—a recognition, expressed in the purposes and actions of the unity or solidarity organization, of the value of self-interest, individual and organizational, as a motivating force toward successful and continuing operation. A unity organization cannot be formed or maintained without the support of engineers; their continued support cannot be obtained unless the unity organization includes among its primary aims, aiding the engineer to improve himself and improving the professional climate for engineering.

Within the engineering profession there already are a number and a variety of organizations; unity organizations, at least in one sense. Engineers concerned with one broad area of engineering, such as civil, mechanical, electrical, etc., have formed societies to work together in developing and promoting an interchange of ideas within those basic areas. Such societies have served, for years, as a core for their members within the technical areas of their competence. They have developed standards and codes for operation and safety that have become recognized and used by many outside of the profession. They have become national authorities and spokesmen within the technical areas of their competence. It must be remembered, however, that their primary reason for existence is to help their individual members develop themselves. This is a prerequisite to all other activities. Similarly, there are local or regional societies or councils that serve the common interests of engineers residing in a community or region.

Some effort must be directed toward self-development of engineers in order to create an organization that will enable engineers as a group to serve mankind without selfishness. When this is done, it will permit the individual members of the profession, and the profession as a whole, to make their greatest possible contribution to the national welfare. This, in turn, will create a climate in which the individual engineer can function more effectively as a recognized professional person.

The AMA and the American Bar Association are virile unity organizations within their professions primarily because they aid doctors and lawyers to develop themselves professionally. True, their contributions to the national welfare are notable, but those organizations are supported because they aid doctors and lawyers to develop themselves.

## AREAS OF UNITY

NEXT, consider the areas in which an effective unity organization in the engineering profession might operate to achieve these goals. There are problems arising

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from time to time within the profession that are generally national in scope and in importance, that the existing societies individually are not equipped, nor in a position to handle. Many of these problems are nontechnical but require a co-ordinated degree of technical competence in several fields.

These problems fall into two broad categories. First, those that affect the individual engineer only indirectly, and in much the same manner as they affect any individual citizen. These might be called national welfare or public service problems. Second, those that affect the individual engineer much more directly. These might be called professional problems.

*Public Service Activities.* In the first category are problems on which a small group of highly competent members of the engineering profession perform a much-needed service to the nation on behalf of the profession. These problems and their solutions are most important. They are being handled now, and have been handled for many, many years. The history of accomplishments in this area is impressive. It can be found in the annals of the Engineering Council of the National Technical Societies in America, founded in 1917, and its heir, The American Engineering Council, formed in 1920. At the current time, this is one of the major areas of the activities of Engineers Joint Council (EJC).

The importance of such activities has been recognized by many prominent engineers. The Honorable Herbert Hoover, first president of The American Engineering Council of the Federated American Engineering Societies, commented succinctly on this in his address to the first meeting of the American Engineering Council on November 19, 1920.[1] Mr. Hoover discusses the "foundation of individualism" upon which American civilization has been built. He goes on to discuss the growth and consolidation of voluntary associations within the economic system and the striving of such associations—employers, farmers, merchants, labor—"by political agitation, propaganda, and other measures to advance group interest."

Mr. Hoover goes on to state: "The Federated American Engineering Societies stands somewhat apart among these great economic groups in that it has no special economic interest for its members. Its only interest in the creation of a great national association is public service, to give voice to the thought of engineers in these questions."

Some examples of these national welfare activities, or service activities, are The American Engineering Council's study on "Waste in Industry" or its survey of commercial aviation in 1925. The latter study resulted in the establishment in the U. S. Department of Commerce of the Bureau of Aviation, the forerunner of the present Civil Aeronautics Authority and Civil Aeronautics Administration.

Current examples are the contributions of EJC to the development of a sound national water policy as reflected in their report, "Principles of a Sound National Water Policy"; or the contributions of EJC through its National Engineers Committee on the Industrial Disarmament of Japan, or in the statement of EJC's Atomic Energy Panel to the Joint Congressional Committee on Atomic Energy, recommending changes in the Atomic Energy Act to permit the engineering profession to make its maximum contribution in the development of atomic energy for peaceful purposes.

*Professional Activities.* Most members of the profession see and understand the necessity for these national welfare or public service activities. Many of them, however, find these insufficient as a rallying point for their own enthusiasm. They will not underwrite a unity organization devoted solely or primarily to such activities. Unless such an organization pursues activities that will help individual engineers to develop themselves professionally, they, in turn, will not give their support or provide the grass roots backing through the technical societies so necessary for the continuity of any successful unity organization to serve both engineers and the nation. Therefore, for this reason, if for no other, there must be concern for problems in the professional area, the solutions to which can be felt by the individual engineer.

In this area, for example, may be considered the problems of the development of the engineer in his profession. This is done through such activities as the accrediting of engineering curricula, the development of standards of ethics, the development of adequate minimum registration requirements, progress toward uniformity of registration, and the like.

Also in this area are studies that have to do with the relations of the engineer with his employer, and the related studies of engineering income, supply, and demand, as well as the problems of monitoring national or area-wide legislation from the standpoint of improving or preventing damage to the climate for the practice of the profession of engineering.

Consider some examples of accomplishments in the professional area. The Engineers' Council for Professional Development (ECPD) has done a noteworthy job in developing engineers, from the time they begin to think about engineering in the secondary schools right through until 5 years after they receive their baccalaureate degrees. ECPD has become the recognized accrediting agency for engineering curricula in the colleges and universities. It has developed canons of ethics that have set the pattern for ethics in the entire profession.

The now-classic report of EJC, "The Engineering Profession in Transition," published in 1946, is another example of a professional area activity. The activities of the EJC Engineering Manpower Commission and the National Society of Professional Engineers (NSPE) in their efforts to improve the utilization of engineers, and their continuing efforts to provide comprehensive and basic information of value to employers of engineers and to engineers themselves in the resolution of their mutual problems relating to working conditions, also might be considered. Another example can be found in the activities of the EJC Labor Legislation Panel. This panel was most successful in having the current professional provisions written into the Labor Management Relations Act of 1947, the Taft-Hartley Act. They have continued their efforts to have these provisions retained in any consideration involving amendment of the Act.

Still a further example can be found in the joint efforts of

EJC and NSPE in successfully having the engineer employee practicing his profession exempted from the provisions of the Salary Stabilization Act.

*Public Relations.* Related to both of these, professional activities and national welfare activities, is the necessity for an over-all public relations program. A successful public relations program will be a partial solution, at least, of the problem of recognition of the engineer by those outside of the profession.

While the problem of recognition needs a considerable amount of effort behind it, there is progress being made in this area too. Through the efforts of EJC and its committees there has been a rapidly growing appreciation of the engineering profession in the Congress. The activities of the EJC Engineering Manpower Commission in its participation in planning for national mobilization have served to underscore the important contribution of engineers to the national economy, and the necessity for forthright action in connection with the mobilization of specialized personnel. They have been successful in arousing an awareness and understanding of this, not only in the Congress, but also within the Department of Defense, and in other executive branches of the government.

## PREVIOUS UNITY EFFORTS

What can be learned from the history of previous attempts to establish a unity organization? The most notable previous unity effort on the part of the engineering profession was The American Engineering Council (AEC) of the Federated American Engineering Societies. The AEC was established in 1920 for the betterment of the profession by opening up opportunities for engineering services in and out of the government. It functioned through a council and an executive committee. The Council was composed of representatives of member societies on the basis of one representative for each 1,000 members. Membership in AEC ranged from a low of 19 societies, 7 national, 5 state, and 28 local societies in 1932, to a high of 54, 8 national, 18 state, and 7 local societies in 1940, the year in which it was dissolved.

The executive committee or administrative board, as it was called later, was composed of 30 members. Actually it was an unwieldy organization from the standpoint of executive action inasmuch as a two-thirds affirmative vote was required by the Council in all decisions affecting policy or action.

Financial support came from assessments of member organizations. Although its membership was national, regional, and local, financial support came primarily from three national engineering societies: The American Society of Mechanical Engineers (ASME), the AIEE, and after 1929, the American Society of Civil Engineers (ASCE). Annual contributions from these three organizations accounted at times for as much as 95 per cent of AEC income, and never amounted to less than 75 per cent.

The major objects of the AEC were: "to further the public welfare wherever technical and engineering knowledge and experience were involved" and "to consider and act upon matters of common concern to the engineering and allied technical profession." During the nearly 20 years of its existence, the AEC made many worth-while contributions to the national welfare through its research activities, and through its services to legislators.

A brief history of The American Engineering Council was prepared by A. F. Bochenek in 1951 after an exhaustive study of the old records of AEC. Mr. Bochenek, a member of the editorial staff of ASME at the time, says in his introduction, "Among those who were active in AEC affairs, there seems to be no unanimity of opinion why the AEC, after the signal achievements of the 1920's, failed to sustain the high level of interest in unity among member engineering societies that was so evident when it was launched during the postwar days of World War I."

In addition to what appears to be one of the major reasons for the AEC's failure, organizational (and financial) defects, there is another possible answer, imbalance of program. To quote further from Mr. Bochenek, in a section covering AEC's services to the engineering profession he says, "While the AEC did serve individual engineers who asked for aid and information, most engineers regarded it as a remote organization working in an indirect and intangible way for the betterment of their profession."

When one considers the success enjoyed by ECPD in comparison, one notes immediately the concentration of its programs on problems and activities in the professional area. To repeat, ECPD is the recognized agency for the accrediting of engineering curricula. ECPD has developed a widely accepted "Canons of Ethics for Engineers" dealing with the relations of the individual engineer with the public, with other engineers, and with his client or employer. ECPD has spearheaded a program, in cooperation with industry and the colleges, to aid the young graduate to develop himself technically and professionally during the 5 years immediately following his baccalaureate degree. ECPD, through its Guidance Committee, has done much to bring the story of the engineering profession to students in the secondary schools and to their parents and teachers. ECPD has developed and is spearheading the acceptance of uniform grades of membership in the technological societies. These activities are appreciated, if not endorsed, by individual engineers.

In summary then, two things can be learned about unity from the failure of the AEC. First, an organization must be planned so that the views of the members of the profession will be considered thoroughly in developing policies within which the unity organization will act. The organization must provide for effective executive action in line with those policies, but without the necessity of continual referral back to the constituent members or affiliates.

In providing a channel of communications through which the views of the members of the profession will be considered, the organization must be so tempered that it will not be subject to violent fluctuations of opinion. This is somewhat similar to the problems faced by the founding fathers of the country in developing its method of government. They designed the policy-making segment of the government to reflect the will of the people through their representatives in the Congress. But this takes time, the Congress is not readily sensitive to rapid changes. It takes time for the will of the people to be reflected in Congres-

sional action. The executive branch of the government has the power to act within the framework of laws (or policy) established by the Congress.

Impatience often is expressed at the apparently inordinate amount of time it takes in the development of laws by the Congress. Time, however, is a great means of tempering. Most people, at times, have been impatient in their own business relations. Most have been tempted to act immediately on some problem, and later have been thankful that they took no action on the spur of the moment.

The second thing to be learned from the failure of the AEC is even more important, the effect of imbalance of program. The efforts of AEC were concentrated primarily on national welfare activities.

Its services to members of the engineering profession were confined largely to two major activities. AEC maintained a roster of more than 115,000 names and records that served as a fountainhead of information about engineers conveniently accessable to government departments and commercial interests seeking the services of competent engineers. They were instrumental, in 1935, in encouraging the Bureau of Labor Statistics to conduct a comprehensive survey that provided, for the first time, reliable information on engineering salaries on a profession-wide basis. As Mr. Bochenek stated, however, most engineers regarded AEC as a remote organization. Thus the grass roots support, and grass roots demand for its continuance, did not exist.

## ENGINEERS JOINT COUNCIL

*Why and How It Came Into Being.* The EJC was organized formally in 1941 as the Engineers Joint Conference. The Conference grew out of a liaison relationship that had existed between the secretaries of the four Founder Societies for many years.

Actually, the Conference was an outgrowth of the Engineering Council of the National Technical Societies of America formed by the Founder Societies (ASCE, American Institute of Mining and Metallurgical Engineers, ASME, AIEE) in 1917. The 1917 Council was formed to work with the government on engineering problems involved in developing the automobile, the tank, and the airplane into major weapons of national defense. When the AEC was formed, the 1917 Engineering Council discontinued its operations and turned over to the AEC its records, its funds, and its Washington office and staff. The liaison relationship between the secretaries that was engendered by this World War I organization was continued.

Early in the mobilization immediately preceding America's entrance into World War II, the Founder Societies received a number of requests from various governmental activities for information and aid in areas of interest to the profession. It was decided that a more formal organization was needed and the Engineers Joint Conference was established in 1941 composed of the presidents and secretaries of the participating societies. The American Institute of Chemical Engineers became the fifth participating member in 1942.

As the scope of activities expanded, the functions of this organization became of greater significance than that implied by "Conference." The name was changed to Engineers Joint Council in September 1945. Representation of the constituent societies on the Council was increased and a formal constitution adopted.

*Expansion of EJC.* In 1949, EJC, through its Committee on Increased Unity, sponsored a meeting to discuss the development of increased unity within the engineering profession. Out of this meeting, an Exploratory Group containing representation from ten other national societies in addition to the five EJC societies was formed. During more than 2 years of study, the Exploratory Group developed a program and plan acceptable to most of its members that was submitted to EJC in January 1952.

After some discussion in EJC, its constitution was modified so that the first step in developing the unity organization in accordance with the recommendations of the Exploratory Group could be taken. The first modification of the EJC constitution changed the requirements for membership to permit the extension of invitations to additional societies to join EJC and, at the same time, provided proportional representation from its members.

The change in constitution was ratified by the five constituent societies of EJC by December 7, 1952, and on December 31, 1952, invitations were extended to eight additional societies to join EJC. Acceptances were received from three: American Water Works Association, The Society of Naval Architects and Marine Engineers, and American Society for Engineering Education, bringing the membership of EJC to eight constituent national societies.

Three of the eight societies invited to join EJC, American Association of Engineers, American Society of Heating and Ventilating Engineers, and the Institute of Aeronautical Sciences, took no action on the invitations extended and they expired on December 31, 1953.

Two of the eight societies rejected the invitation to join EJC. In its letter of rejection, the Institute of Radio Engineers (IRE) requested continued co-operative activity with EJC on specific problems of mutual interest. Their rejection was dictated by two basic policies of long standing. First, that IRE shall not engage directly or indirectly in legislative activity. Second, that IRE as a society is not entitled to represent its members as individual members of the engineering profession, or, as a body, on social or general professional matters, and shall not, as a society, take a stand even on technical matters.

After considerable study, and additional meetings between a special joint committee consisting of three members of EJC and three representatives of NSPE, the latter organization declined to accept the invitation to join EJC. In the resolution adopted by the board of directors of NSPE on November 7, 1953, the invitation was declined "at this time, in accordance with the firm conviction of this Board that no organization can adequately represent the engineers of this nation, unless that organization is based primarily on individual membership and constituted to assure prompt and effective means of communication between the individuals, their local or state units, and their national governing body." The resolution goes on to express the firm desire of NSPE to continue mutual efforts toward the most effective action possible between the two organizations.

While NSPE did not accept at this time, the study resulting from the joint committee did much to further a mutual understanding between the two organizations. In addition, it has provided a very valuable document for the guidance of EJC. The Joint Committee on Relations Between EJC and NSPE is being continued by both organizations further to explore areas of mutual co-operation between the two societies.

*Organization and Objects of EJC.* The present Council itself is composed of 19 representatives of the eight constituent societies in proportion to their membership. Representatives and alternates on the Council must be members of the governing boards of the societies they represent. The presidents of the constituent societies are members ex-officio of the Council. The president and vice-president of EJC and the members of the Executive Committee are elected from among the representatives at the Annual Organizational Meeting to serve for one year. The EJC constitution provides that the president, the vice-president, and the other members of the Executive Committee each must be from a different society.

The objects of EJC as expressed in its constitution are as follows:

1. To advance the general welfare of mankind through the available resources and the creative ability of the engineering profession.
2. To promote co-operation among the various branches of the engineering profession.
3. To advance the science and the profession of engineering.
4. To develop sound public policies respecting national and international affairs wherein the engineering profession can be helpful through the services of the members of the engineering profession.

There is ample recognition here of the necessity to provide a balanced program. EJC actually carries on activities in both the national welfare or public service area and also in the professional area.

*Public Service Activities.* EJC's activities and the work of its committees fall into both of the broad areas previously mentioned, national welfare or public service activities, and professional activities.

In the first category, its Committee on Engineering Sciences co-operates with the National Science Foundation in initiating and developing basic research in the engineering sciences. That committee also assists members representing engineering on the National Science Foundation Board. It has a task committee working actively with the National Science Foundation on the development of the engineering section of the National Scientific Register.

The EJC Committee on International Relations acts as a co-ordinating agency between the profession in the United States and abroad. The committee has been working actively with the Pan American Federation of Engineering Societies (more familiarly known as UPADI from the Spanish title, Union Panamericana de Asociaciones de Ingenieros). EJC is the United States member of UPADI. The Committee on International Relations was instrumental in helping to rebuild the engineering libraries of war-torn countries by acting as a clearinghouse for contributions of books that were delivered through the medium of the United States Book Exchange.

EJC also has an Advisory Committee to the Lewis Historical Publications, the official publishers of "Who's Who in Engineering." There is representation, not only from the eight constituent societies of EJC, but also from the Institute of Aeronautical Sciences, Engineering Institute of Canada, the IRE, Society of Automotive Engineers, and NSPE.

In addition to its work on the industrial disarmament of Japan, EJC's National Engineers Committee has continued to function in an advisory capacity to government agencies such as the Federal Civil Defense Administration, and the President in connection with the establishment of the St. Lawrence River Joint Board of Engineers.

*Professional Area Activities of EJC.* In the area of professional development, EJC is continuing, through its Special Surveys Committee, its surveys of supply, demand, and professional income. NSPE is represented on that committee also. A study of "Professional Income of Engineers in 1953," covering the income of nearly 70,000 engineers employed in industry, education, and government recently was released.

The Engineering Manpower Commission of EJC has been working actively for the past 3 years to secure the most effective use of engineers in the national health, safety, and interest. In this area, it has done much to stimulate the interest of qualified high-school graduates in careers in engineering. It also has done much to promote more effective utilization of engineers, not only by the government, but also by industry.

Of major significance in the professional area, however, is the work of two committees. First, the Committee on Employment Conditions, through the constituent societies, has been making a study of employment conditions for engineers. While its work is not yet complete, that committee is studying the interest of engineers in collective bargaining, in professionalism, and in other activities which affect their employment conditions.

Second is the Committee on Recognition of Specialties in Engineering. As a result of a suggestion that came to EJC through the Joint Committee on the Advancement of Sanitary Engineering, a committee was formed to consider the problem of recognition of specialties in engineering. This need was emphasized by the difficulties encountered by sanitary engineers in being recognized as competent within their specialty, especially by those outside of the engineering profession. Sanitary engineers work very closely with members of the Public Health Service, and with the medical profession.

After the EJC Committee on Recognition of Specialties was established, the problem was discussed with the Joint Committee on the Advancement of Sanitary Engineering and the EJC committee is watching with a great deal of interest the work being done by the joint committee in developing plans and procedures for recognition of sanitary engineering as a specialty.

Current thinking is along the lines of specialty boards to examine candidates in a somewhat similar manner to that

employed in the medical profession. When the plans and procedures have been worked out in full detail and have been tested in the pilot study on sanitary engineering, they unquestionably will be extended to other fields cutting across the interests of more than one of the constituent societies. Hydraulics and nuclear engineering are two examples.

*Other EJC Activities.* EJC is in the process of changing. It is entirely different now than it was 2 years ago. As its activities progress, and as the Council studies and implements the recommendations of the Exploratory Group, it will continue to change. It can become the unity or solidarity organization for the profession.

In this connection, there are two most important activities. One of the recommendations of the Exploratory Group concerned the affiliation of state, regional, and local societies with EJC. A special committee now is working actively on that problem. That same committee also is studying the affiliation of national societies that meet all the requirements for EJC membership except that of size.

The second activity of interest is the matter of individual participation in EJC. This is deemed to be of such importance that the Executive Committee itself is devoting additional time to the problem.

It is hoped that the individual members will follow news of EJC and submit their suggestions for improvements, especially improvements that will help build EJC into the organization which engineers want and need.

## CONCLUSIONS

If, in its activities, EJC gains the support of the individual members of the engineering profession, it can become the unity organization that engineers have been looking for. In order to be successful, however, it must have the interest and support of the individual engineer.

However, those who desire a collective bargaining agency as a unity organization will have to look elsewhere. EJC cannot and will not become a collective bargaining agency, nor will the existing technological societies.

To those who point to the strength of unity organizations in the medical and legal professions remember that both of those professions are predominantly self-employed. There is no collective bargaining problem there. To attain public recognition and true professional status, especially in the eyes of the public, initiative, resourcefulness, creativity, and individual incentive must be encouraged among the members of the profession. These will be the tools through which engineers can be developed professionally, the practice of engineering improved, and the profession can provide effective services to the national welfare, or in the public interest. These factors are the direct opposite of collective bargaining.

Engineers as professional people have an obligation to devote a share of their time, efforts, and funds as a service to the nation in matters affecting the national welfare or in the public interest. If they do not carry on such activities, they will not maintain a professional status.

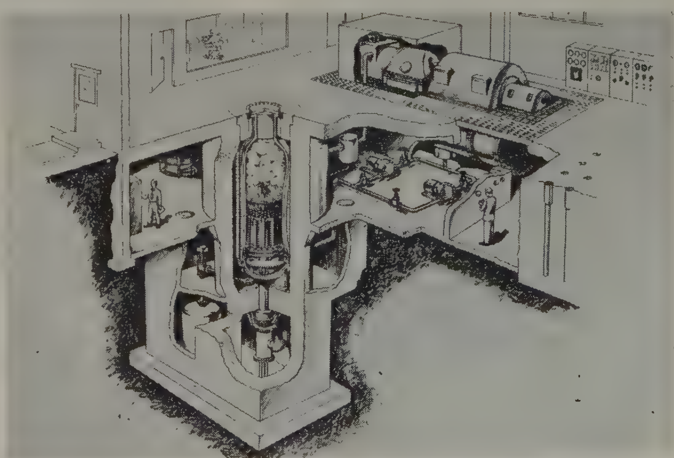
Activities of the type carried on by EJC are mandatory. It is of tremendous significance that only a year after AEC ceased its operations, engineers were forced to form another organization, EJC, to fill this need or concede that the engineering profession as a whole was voiceless in matters of national concern. Since 1917, there has been, except for 1 year, an organization engaged in such activities.

A successful and continuing unity or solidarity organization to serve the engineering profession can be built upon the framework already established in EJC and the developments it is undergoing, if engineers will lend it their constructive support. Unless EJC is built into the spokesman for the profession in these areas of activity, engineers will find themselves represented by other, less-qualified, organizations hardly distinguishable from labor unions. What engineers, as individuals, get from EJC, or from any other organization for that matter, will be in direct proportion to what engineers as individuals put into it.

## REFERENCE

1. Some Phases of Relationship of Engineering Societies to Public Service, **Herbert Hoover.** *Mechanical Engineering*, New York, N. Y., vol. 42, December 1920, p. 722.

# Experimental Boiling Water Reactor for Nuclear Power Plant



**Shown at right is an artist's conception of an experimental boiling water reactor, part of a program recently announced by the Atomic Energy Commission for the peacetime development of atomic power. This experimental plant, with an output of 5,000 kw, follows investigations by Argonne National Laboratory of a small temporary reactor in which water is converted into steam directly without the use of an intermediate heat exchange system. The tall, cylindrical tank in the center of the picture is the pressure vessel, cut away to reveal uranium fuel assemblies and water being converted into steam. The steam is carried to the turbine and electric generator in the upper right of the picture. The control room is to the left of the generator. A condenser, in which steam leaving the turbine becomes water again, and pumps for returning this water to the reactor are below the turbine and generator. The holes in the concrete on the right are for storing highly radioactive partly used fuel elements, pending disposal**

# A Step Forward in Printing Telegraphy

A. S. BENJAMIN
MEMBER AIEE

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**The objectives in the development of a new integrated line of Teletype apparatus especially designed to serve adequately both present and future printing telegraph applications are described together with the Teletype Model 28 Direct Keyboard Page Printer Set. It is composed of a page typing unit, keyboard, electrical service unit, and their motor drive and cabinet housing.**

RECENT commercial and military printing telegraph communication requirements could not be met fully in an efficient and economical manner with existing equipment. Therefore a new integrated line of Teletype apparatus has been designed especially to serve adequately present and future printing telegraph applications exemplified by the Teletype Model *28* Direct Keyboard Page Printer Set shown in Fig. 1. This set consists of a page typing unit, keyboard, electrical service unit, and their motor drive and cabinet housing. The other units which soon will be available are the tape perforator, tape typing unit, and transmitter distributor which, with the keyboard and page typing unit, are designed to be arranged readily in many combinations to meet specific applications. Fig. 2 indicates the basic units and a few representative combinations.

Full text of paper **54-115**, "A Step Forward in Printing Telegraphy," recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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### HISTORY OF PRINTING TELEGRAPHY

COMMERCIAL telegrams were transmitted using printing telegraph machines as early as 1851, 7 years after the commercial introduction of Morse. Modern printing telegraphy got its start in 1910, with the invention by Howard L. Krum (*U. S. Patent 1286351*) of the start-stop method of synchronization applied to printing telegraphy. Commercial success came in the early 1920's at which time such equipment was used primarily by the commercial telegraph companies and press associations. In 1930 printing telegraph moved rapidly into the business field and since 1940 the extensive use of that form of communication in military service has occurred.

The original applications presented no great problems. Direct circuits were set up between telegraph offices or between press sending stations and receivers located in newspaper offices. Forty-word-per-minute speeds were considered adequate, messages were printed on plain paper fed from a roll or on individual blanks inserted by operators, and due to the fact that equipment was concentrated in large centers, only a relatively small number of maintenance men were required.

As the business field applications grew, the speed went up to 60 words per minute and new requirements were introduced which resulted in the development of various accessories which were attached to existing units or installed separately. Since the original design of the units did not anticipate many of these functions, the parts for a given mechanism were placed wherever there was space with the result that the equipment was somewhat difficult to maintain. These added features included sprocket feed, horizontal and vertical tabs, motor control, contacts for various switching and control purposes, etc. The space for these mechanisms was limited and it soon became necessary to use external units to provide the multiplicity of control functions.

The 60-word-per-minute speed became too slow for certain applications and the equipment was modified for 75-word operation. Attempts were made to increase

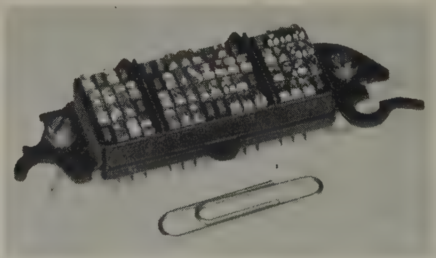

**Fig. 1 (left). Teletype Model 28 Direct Keyboard Page Printer Set consisting of page typing unit, keyboard, electrical service unit, and their motor drive and cabinet housing. Fig. 3 (above). The typebox here shown in comparison with an ordinary paper clip**

the speed to 100 words; however, high maintenance costs severely limited this use.

The installation of printing telegraph equipment on ships, planes, and trucks imposed requirements of satisfactory operation at various inclinations and under conditions of great vibration.

As business expanded the use of printing telegraph techniques, the systems became larger and more complicated. Automatic switching was introduced and printers were installed in hundreds of offices of a single user. The Bell System TWX Service, which is similar to telephone exchange service except that printers are connected through switchboards for typewritten communication, now has more than 35,000 Teletype sets distributed over the entire country. Each of these fields of use required new types of equipment. In almost all cases the equipment was wanted in a hurry, and since the future demand was uncertain, each new piece of equipment generally was provided by modifying an existing machine. This obviously did not result in an orderly development of standardized equipment.

## OBJECTIVES OF NEW MODEL 28 LINE OF EQUIPMENT

It became evident that a new line of equipment was needed which would meet the following prime objectives:

1. An integrated group of component units.
2. Lower maintenance costs.
3. Quieter operation.
4. Increased speed.
5. Greater capacity for additional functions.
6. Decreased weight.

A review of the typing mechanisms used in Teletype units of various kinds and those developed by other printing telegraph producers indicated that they were generally unsuited to meet the new requirements. Typebar carriages were considered too heavy and typewheels difficult to index at high speeds. Existing clutch designs similarly

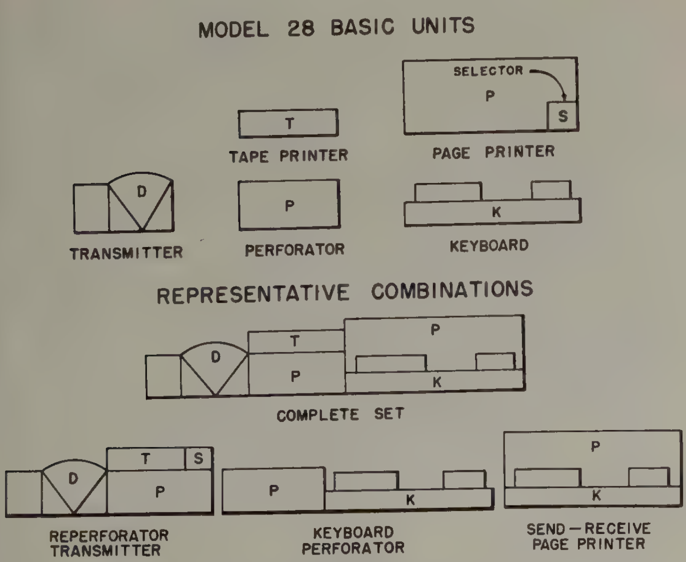


**Fig. 2. Model 28 basic units and representative combinations**

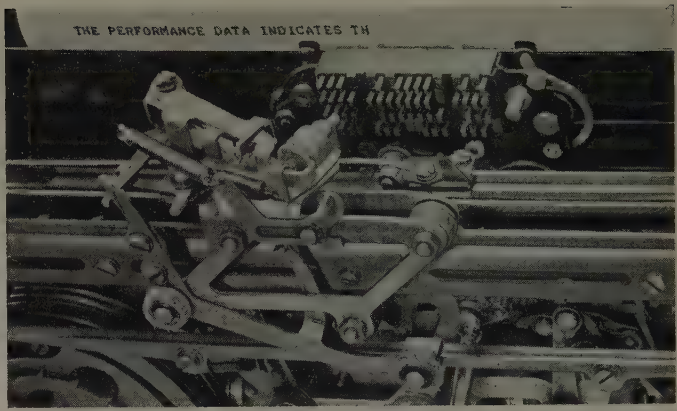


**Fig. 4. The printing hammer drives the type pallet against the ribbon and paper when the typebox is in the desired position**

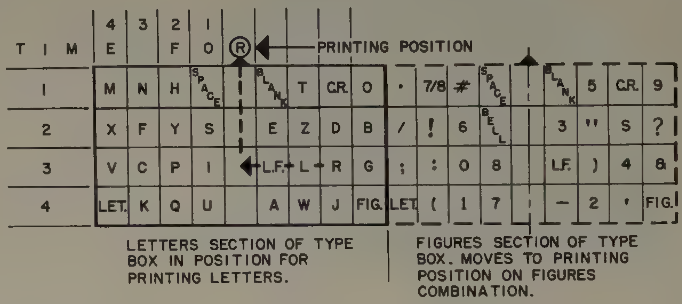


**Fig. 5. Typebox arrangement and printing method**

were considered inadequate, felt clutches always having been troublesome due to heat and loss of lubricant and positive clutches subject to breakage due to impact. It therefore was decided to design new elements specifically to meet the requirements of today and the next 10 to 20 years.

1. *The printing mechanism* is the most obvious of the several improvements in the new machine. The type pallets, instead of being mounted on bars in the conventional manner, are carried in a small rectangular box about 1/2 inch thick, 1 inch wide, and 2 inches long (Fig. 3). There are 64 pallets arranged in four horizontal rows, each row having a capacity of 16 characters. To type a character, the typebox is moved to bring the desired character to the printing point, and a printing hammer, shown in Fig. 4, operates to drive the type pallets against the typewriter ribbon and paper. Each pallet is provided with a return spring that restores the pallet to its normal position after printing. After the printing hammer has operated, the typebox returns to its initial position below the printed line on the paper, so that the typing becomes visible.

Characters in the left half of the box are letters; those in the right half are figures. A shift mechanism is used to change from letters to figures. The normal position of the typebox for letters' selection is as shown in Fig. 5. When figures are to be printed the centerline of the figures group is moved to the printing position. Movement of the typebox, in selecting the desired character to be printed, is controlled by two index mechanisms, one controlling

the vertical motion to select the proper row of type, and the second controlling the horizontal motion to select the desired character in that row. These motions together form a rectangular co-ordinate system for all the 32 permutations of the standard 5-unit telegraph code.

The five elements of the code are used to position the pallet in a different manner than on other telegraph apparatus units. The first two elements of the code are used to determine the vertical position of the box—in other words, the number *1* and *2* impulses, by their presence or absence in the code permutation, will cause the printer to select one of four levels on the typebox for printing. The number *3* impulse determines which way the box will move from either the letters or figures centerlines; that is, either to the right or left. The number *4* and *5* impulses determine how far the box will move in the selected direction; there are four locations in each. The code combination for *R*, as shown in Fig. 5, causes the box to move upward three levels, to establish the leftward direction, and to move three spaces in that direction, thereby bringing the *R* type pallet in line with the printing hammer.

A unique toggle-type coupling mechanism is provided in the drive system so that the typebox can be stopped in various positions in a gentle manner and without noticeable impact. With this mechanism, the movement of the typebox toward its final position is at high speed, but as the typebox approaches the selected position, the toggle mechanism reduces its speed. At the end of the typebox travel, where further motion is blocked by the index mechanism, the speed of the typebox is about one-fifth of that at which it would have passed this position.

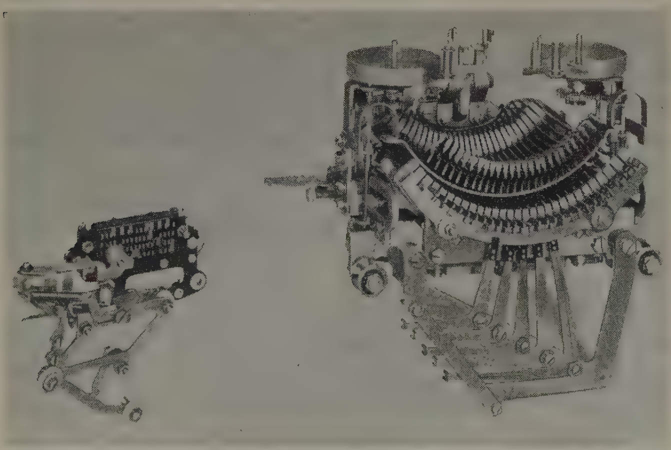

**Fig. 6. The new typebox assembly shown with the older moving-type basket carriage which weighs ten times as much as the new assembly**

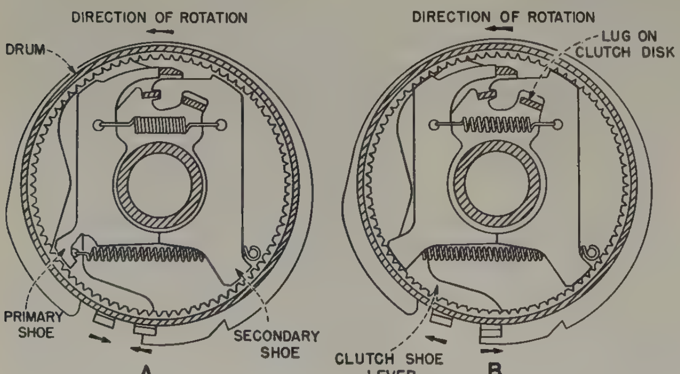


**Fig. 7. Internal expansion friction clutch**

*A—Clutch disengaged; B—Clutch engaged*

**Fig. 8. The stunt box containing code bars for performing non-printing operations such as line feed, carriage return, shift, etc.**

Elimination of the conventional type basket greatly reduces the size and weight of the carriage that travels back and forth across the page, starting and stopping for each character printed. A comparison of the old and new type assemblies is illustrated in Fig. 6. In a standard Model *15* typing unit, the moving carriage assembly weighs slightly over 5 pounds; the carriage assembly in the Model *28* has a total weight of 8 ounces. This 10 to 1 weight reduction results in a very fast carriage return, the carriage returning easily within time of two character intervals (signals received for carriage return and paper feed) at 100 words per minute. Gravity has no significant effect on the carriage motion. The machine can be operated safely on shipboard or in other locations where it might not be in a level position.

Since the pallets are carried in an accurately made box instead of at the ends of the type bars, as in the older machine, type alignment is controlled by manufacture of the parts with no further adjustment required. Stability of alignment, too, is greater, and this should reduce maintenance.

This small lightweight carriage also makes possible an over-all reduction in size and weight of the machine, and permits the use of stamped sheet metal framing instead of the massive cast framework used on the older machines. The weight of the Model *28* Teletype printer set is 38 pounds, not including the cabinet and accessories.

At the right end of the typebox, a small manually operated clamping lever holds the box in its supporting carriage. This clamping lever may be released with a light finger motion so that the typebox can be withdrawn from the machine without using tools. Thus the box may be cleaned easily without brushing dirt into the mechanism of the machine. Also, the typebox may be exchanged in a matter of seconds for another having

different character faces. On older types of equipment with individual type, it is necessary to solder type pallets to typebars and realign them.

Since each character is separately mounted on an individual type pallet, only one operates at a time. In the older machines, with two characters on a single pallet, there is a possibility of printing part of the other character on a pallet if the adjustment is not exact, or if one of the characters is worn, or if several carbon copies are being made so that the surface of the paper is somewhat spongy. The Model *28* is capable of making the same number of carbon copies as present machines, and because the same hammer blow is applied for all characters, the printing impression is more uniform than that of a typebar machine. This characteristic is very important when a large number of copies are being made. The printing blow can be increased readily for multiple copy work by adjusting the tension of a spring by means of a manually operated position lever (Fig. 4). Due to the simplicity of the printing mechanism, it is possible to make the shift from figures to letters and conversely within the printing mechanism rather than by raising and lowering the platen roller. This simplifies paper handling and improves the readability of the printed record, since the paper remains stationary at all times except during line feed.

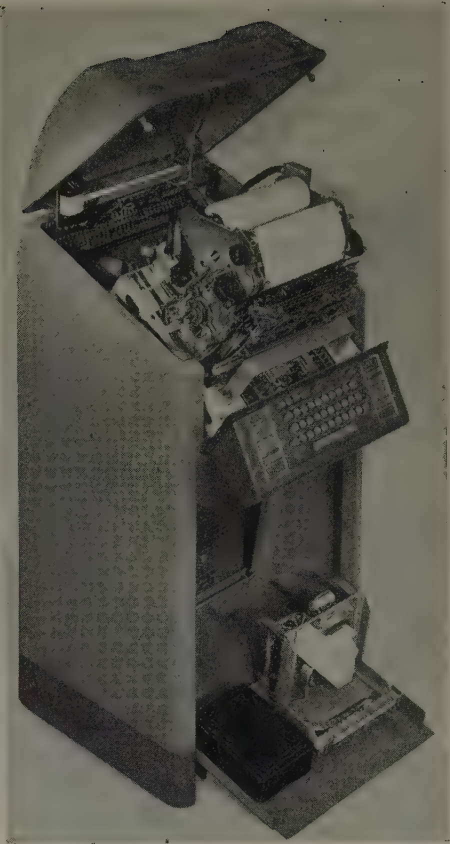

**Fig. 10. The Model 28 equipment shown here is mounted pivotally in the cabinet and swings outward for maintenance. Incoming wires are connected to terminal blocks behind the typing unit**

2. *The ribbon spools* are mounted on the machine itself rather than on the type carriage, thus providing a straight course for the ribbon travel. This not only facilitates changing ribbons, since the path is obvious and the number of guides is a minimum, but in combination with the more gentle blow of the new type hammer, it results in increased life of the ribbon as compared to the older machines.

3. *A newly designed clutch* is another machine element that improves operation, reduces maintenance, and contributes to good receiving margins—that is, ability to tolerate distortion of signal pulses. Clutches of the new design are used not only for driving the selector cams, but for the various other power actions, such as moving the typebox, feeding the paper, spacing, etc. This clutch is an all-steel internal expansion friction clutch, that disengages in the stopped condition, whereas the older clutch depends upon slippage between felt washers and steel plates when a stop is interposed, so that the driven member is held mechanically from turning. Fig. 7 illustrates the method of operation. The continuously rotating driving member is a steel drum, the inner surface of which is grooved, hardened, and ground to give a flat surface on the tops of the grooves. The grooves between the flat surfaces permit wear products to fall away from the working surfaces. Within this drum, two hardened steel members act as drive shoes and are pressed into contact with the rotating drum by a spring-operated pry bar. The leverage system is so designed that through a system of very rigid force-multiplying levers, a small spring produces high normal pressure between the hardened steel friction surfaces. Since the clutch disengages in the idling position, the load on the motor at that time is very small. Life of the clutch equals that of the rest of the machine.

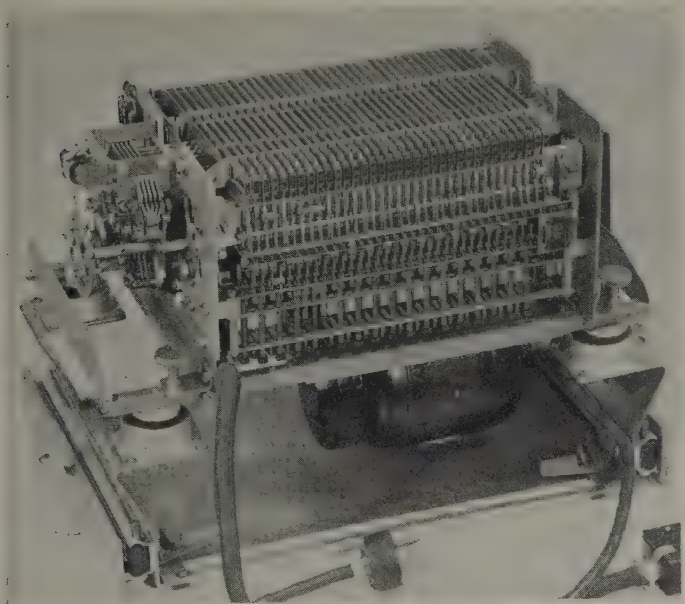

**Fig. 9. The sequential selector which has been replaced by the stunt box in the Model 28 set**

4. *Performance of nonprinting operations*, such as line feed, carriage return, and shift, is controlled by a new mechanism contained in a separate subassembly called a "stunt box." This unit, which is accessible from the rear, extends across the full width of the typing unit and engages code bars that also extend across the machine. The function bars (Fig. 8) of the stunt box engage notches in the code bars. The stunt box has 42 slots, each of which may hold a function bar capable of responding to an assigned code, making it possible to control 42 functions. Approximately ten are

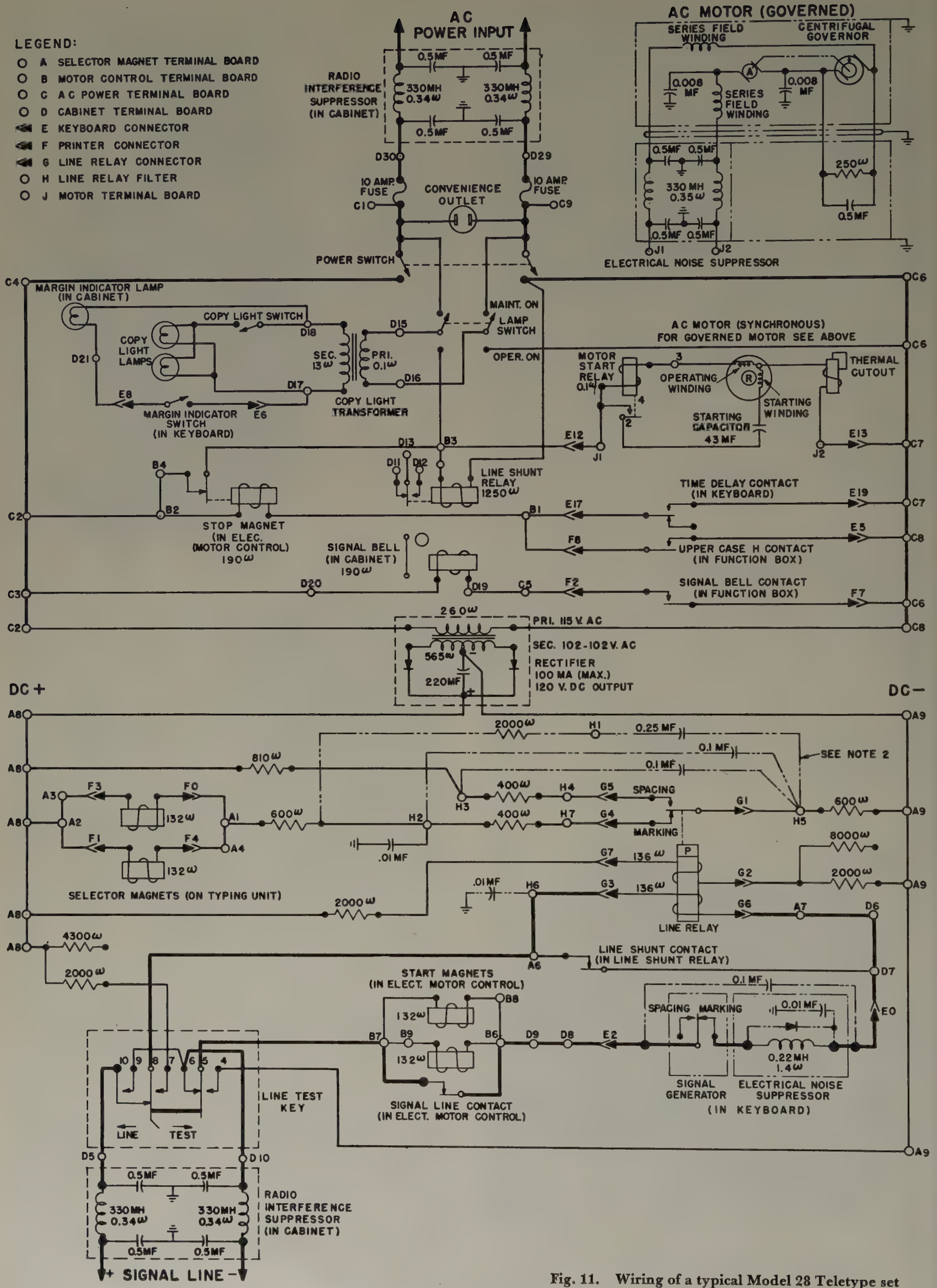


**Fig. 11.** Wiring of a typical Model 28 Teletype set

reserved for the common functions, such as line feed, carriage return, and shift, and the remaining 32 are available for special purposes. Stunt boxes are interchangeable. The stunt box may be arranged to perform the functions of the sequential selector unit shown in Fig. 9 which controls circuits from groups of character combinations sent in a predetermined sequence.

5. *The keyboard mechanism* in the Model *28* also is different from earlier designs. When the operator depresses a key, a latch is tripped which permits the code bars to move endwise by spring action. In the older machines, depressing a key moved the code bars directly, so that there was considerable variation in the forces required for different code combinations. Thus the new action results in a lighter, shallower, and more uniform key touch.

When the key lever is depressed, one of the bars that moves longitudinally trips the clutch latch and allows the clutch to engage a cam-operated mechanical distributor. This causes the code pattern to be translated into a start-stop electric signal, the signal itself coming from the signal generator.

6. *The signal generator* is a single contact assembly mechanically operated by the distributor. This contact has the form of a transfer switch and therefore permits either open or closed signal transmission or transmission of signals of alternate polarity. The contact is mounted in a metal box for mechanical protection and shielding against radio interference, and requires no adjustment other than in positioning the box itself.

7. *The cabinet for the new machine* was designed to suppress machine noise, improve operating convenience, and provide better appearance. The equipment is housed in a new floor model (Fig. 1) with all mechanical controls brought to the front so that the machines can be mounted side by side in rows. Even the manual platen crank has been eliminated and replaced with a rapid motor-driven feedout controlled by a button on the keyboard. A lamp within the cabinet illuminates the copy, and the angle of the window above the copy has been chosen so that glare practically is eliminated. The upper section of the cabinet swings open to provide access for insertion of paper and ribbons and for maintenance. Fig. 10 shows how the equipment may be swung upward and forward to give access to both sides and rear of the machine.

### ELECTRICAL FEATURES AND CIRCUITS

Electrical accessories such as the line relay, motor control relay, rectifier, fuses, and others, have been placed in a box behind the machine. The interconnections between the several units have been made simple and flexible which permits installation of a standard machine where circuit termination requirements vary. In the cabinet below the printer there is a shelf on which a front panel is pivotally mounted, as shown in Fig. 10, providing mounting surfaces for auxiliary equipment if this is desired.

The equipment is driven by a synchronous motor when 110-volt regulated alternating current is available or by a governed motor when unregulated alternating current or direct current is available. Printing telegraph equipment requires speed control of ± 1 per cent; the governor used on the Model *28* which is of new design will maintain the speed and, once adjusted, it generally will hold speed for the life of the motor brushes, even if the governor contacts wear or pit considerably. The older type of governor requires frequent readjustment and maintenance and is subject to speed change due to comparatively slight wear or pitting of contacts.

The wiring of the Model *28* Teletype set described herein, equipped with the most commonly used electrical features, is shown in Fig. 11.

### CONCLUSION

Since operating experience indicates the Model *28* Page Printer Set requires less maintenance than other printing telegraph equipment, it is expected that its field of use will be extended to include more remote locations.

The other units of the new line—the tape printer, perforator, and reperforator transmitter—have undergone extensive tests which indicate they will give the same service as the Page Printer. These units also have new and novel features and will be available in the near future to serve the needs of printing telegraph users.

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## World's First Commercial Moving Sidewalk Being Built

The world's first commercial moving sidewalk soon will be in operation between the stations of the Erie Railroad and the Hudson and Manhattan Railroad in Jersey City, N. J. It can handle 10,400 passengers an hour through the interstation tunnel. The 227-foot conveyor, being built by the Goodyear Tire and Rubber Company and the Stephens-Adamson Manufacturing Company, is called a "Speedwalk." General Electric Company engineers, working in conjunction with Goodyear and Stephens-Adamson, developed the electric system. The equipment includes a fan-cooled motor, a combination reversing starter (fusible type), and a thrustor brake.

The new conveyor will utilize a 6-ply rubber and fabric conveyor belt, $5^1/_2$ feet wide and $^5/_8$ inch thick. It will be driven at a speed of $1^1/_2$ mph (about half normal walking speed). For 127 feet of its length, the Speedwalk will carry passengers on a 10-per-cent grade. Handrails will move at the same speed as the belt and passengers will be able to step on and off as if it were an escalator. The belt will move in whichever direction the traffic is heavier.

The reversing starter and totally enclosed 1,200-rpm fan-cooled motor both are rated at 20 hp, 220 volts, 3 phase, 60 cycles. The thrustor brake is rated 600 pounds-feet continuous and 800 pounds-feet intermittent.

# Analyzing Rotating Machinery by Network Theory—I

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STATIC NETWORK THEORY can be extended to the analysis of rotating machinery to obtain the present concepts in machine analysis and, at the same time, develop the precision and procedures necessary to analyze more complex problems. It is believed that the unity, the fundamental characteristics of the procedures, and the concept of a transformation of variable involved in this extension lead to a clearer understanding of the problem and to a marked increase in the complexity of problems that can be solved.

When the rotating machine is considered as a "dynamic network," the analysis problem reduces to one in which there is relative motion between the elements of the network, thereby giving rise to self- and mutual inductances that are functions of time. The voltages resulting from these time-varying inductances are represented by the total derivative of the inductance-current product, $\frac{d}{dt}M(t)i(t)$. The first step in the analysis is to establish a good map or connection diagram of the machine showing how all the elements are connected, showing a reference for all currents and voltages, and, finally, showing a set of magnetic polarization reference marks for all elements. Any network connected to the terminals of the machine is included in the diagram. The magnetic coupling between the elements is determined as a function of rotor position by use of the magnetic polarization reference marks from a second map which shows the physical orientation of the elements of the machine. The inductance coefficients used in the analysis can be evaluated by conventional methods.

The starting point in the analysis of any network is the differential equations. The mesh-circuit differential equations for the rotating machine, as written from inspection of the connection diagram following the usual techniques of circuit analysis, have variable coefficients and are very difficult to solve under the general transient conditions of operation. However, if only the steady-state (particular integral) solution of the equations for a machine operating under the usual highly restricted conditions is required, the equations can be solved in their original form by following the standard technique of assuming the form of the solution and evaluating the constants. In so doing, the concepts used in rotating field theory are obtained with less effort and more precision than by presently accepted methods. From this point of view, the analysis of the single-phase induction motor is less complex than that of the polyphase machine, it being quite apparent, for example, that the machine can develop no torque at standstill or synchronous speed.

When the transient (complementary) solution to the variable coefficient differential equations is required, or when the steady-state (particular integral) solution for unusual conditions of operation is required, it is necessary to apply a transformation of variable to remove the variable coefficients. Any transformation of variable on all or part of a set of linear simultaneous equations is clearly and efficiently effected by the use of matrix algebra. From this point of view, the direct and quadrature axis theory introduced by Blondell appears simply as a transformation of variable and all transformed impedances, currents, and voltages are clearly and rigorously defined in terms of the original variables by forming the appropriate matrix products. The transformation matrix in this case contains variable coefficients and is applied only to the armature (primary) circuits. The inductances of the secondary circuits of the induction machine are independent of time if the slot effects are neglected. However, since there are several secondary circuits, much simplification results when a transformation of variable is applied also to the secondary currents and voltages, thereby diagonalizing the impedance matrix of the secondary and rendering the equations of the secondary independant. One such transformation when applied to the secondary circuits leads immediately to the cross-field theory of induction machines, both single-phase and polyphase.

The concept of a transformation of variable is equally useful where other objectives are sought. For example, much improvement in accuracy results in the analysis of multiwinding transformers when a transformation of variable is applied which effectively produces a set of equations, the coefficients of which are the differences between the self- and mutual inductances of the windings. When applied to the 2-winding transformer, this type of transformation immediately produces the familiar T-equivalent network of the transformer with all quantities referred to the appropriate side. Symmetrical components also can be considered as a transformation of variable. However, this transformation of variable is only applicable to steady-state analysis after the equations have been written in complex impedance form.

The concept of a transformation of variable is most important when the rotating machine is considered as a network problem. Without the concept of a transformation of variable the differential equations would be of little practical value and the necessary accuracy could not be obtained. When this important concept is used in conjunction with network theory and matrix algebra, the analysis of rotating machinery follows as a logical step in the extension of network theory, thereby permitting the development of a method of analysis equally applicable to all type circuits, dynamic or static.

Digest of paper 54-87, "Application of Network Theory to the Analysis of Rotating Machinery. Part I—Synchronous and Asynchronous Machines," recommended by the AIEE Committees on Basic Sciences and Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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# Methods of Starting Gas-Turbine-Generator Units

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ALTHOUGH GAS-TURBINE power plants eliminate the need for much of the equipment associated with steam turbines, they present some special problems such as how to accelerate them to their self-sustaining speed.

A gas-turbine-generator unit normally consists of a rather conventional turbine generator, excited by a direct-connected exciter, and driven by either a direct-connected or a geared gas turbine. The gas turbine portion of the unit consists of one or more turbines and air compressors, the combustor, and heat exchangers as required. The physical arrangement of the major components depends upon the type of gas-turbine cycle used. This influences the starting requirements and the location of the starting device. Three typical gas-turbine arrangements are illustrated in Fig. 1.

Possible starting devices include internal combustion engines, expansion turbines, and various a-c and d-c motors. A representative design is a 5,000-kw unit, consisting of a 250-hp 4-pole wound-rotor induction motor cranking through a step-up gear, a disengaging clutch, and a special exciter coupled to the 3,600-rpm generator. Various starting devices could be used with this arrangement. The gear at the motor permits cranking assistance above 50-per-cent turbine speed to be obtained from a 4-pole 60-cycle motor. The clutch allows this relatively low-speed motor to be disconnected and permits it to cool itself by running unloaded.

Usually the compressors for gas turbines must be cranked above 20-per-cent speed before firing. After light-off, assistance is required to approximately 60-per-cent speed, above which the turbine is self-sustaining. Fig. 2 shows typical speed-torque requirements of a gas-turbine unit. Typical acceleration time is 3 to 6 minutes. Two duty cycles are recommended. One accelerates the unit twice from turning-gear speed to light-off speed and once from light-off speed to self-sustaining speed. The other cycle accelerates the unit to a spinning speed (comparable to light-off speed), maintains that speed for 15 to 30 minutes, and then accelerates the unit to self-sustaining speed. This second cycle is useful during inspection and adjustment during initial operation or following a prolonged shutdown. It is used also for cooling turbine parts rapidly during the initial portion of a shutdown period. A cooling period follows each cycle.

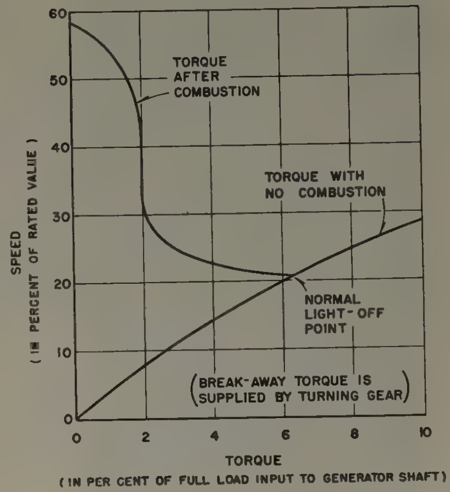


**Fig. 2. Speed-torque requirements for starting simple open-cycle 5,000-kw gas-turbine - generator unit**

When cranking with an induction motor, it is important to maintain rated voltage at the motor. A voltage drop increases the starting time and may prevent the motor from reaching the required speed. Excessive starting time could overheat the motor, designed for intermittent duty.

Since gas turbines are finding an increasing number of applications as prime movers for electric power generating units, the problem of cranking them should interest power plant engineers in the years to come.

Digest of paper 54-37, "Methods of Starting Gas-Turbine-Generator Units," recommended by the AIEE Committee on Power Generation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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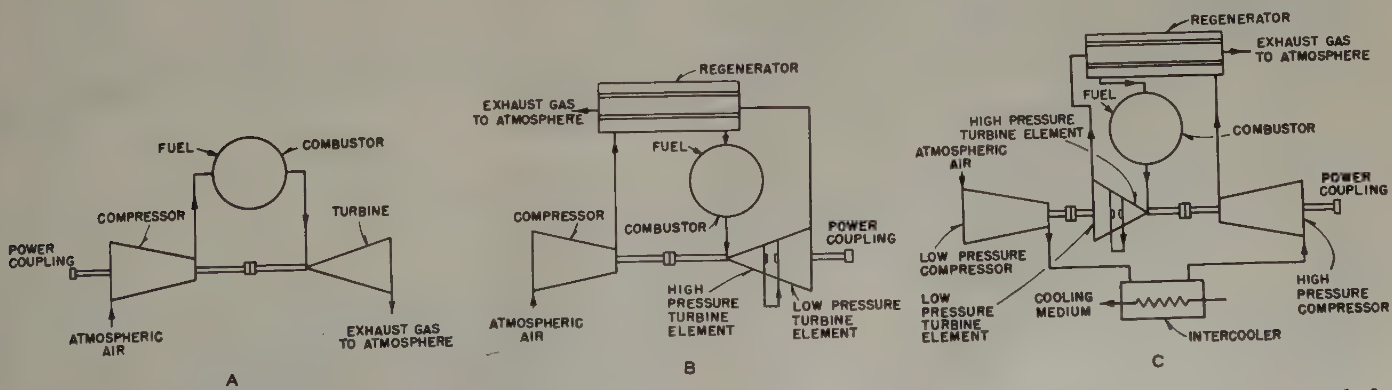


**Fig. 1. Gas-turbine power plant. (A) Simple open cycle, single shaft, (B) Open cycle with regenerator, series flow, two shaft, (C) Open cycle with intercooler and regenerator, series flow, two shaft**

# Unbalance of Single Circuit Lines

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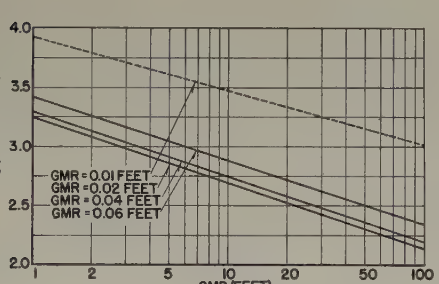
IN RECENT YEARS, many new overhead lines have been built without transpositions in the individual line section and experience has indicated that transpositions are rarely necessary. The elimination of transposition structures leads to geometrical unsymmetry of the phases along the line section, and consequently to small electrostatic and electromagnetic unbalances. In this study are investigated characteristic electromagnetic unbalance factors of various configurations of single circuit lines, i.e., various triangular and flat arrangements without and with ground wires.

In order to compute approximate values[1] of circulating negative sequence and zero sequence currents, $I_{a2}$ and $I_{a0}$ respectively, which are due to the balanced load currents $I_{a1}$ and the unsymmetry of the line configuration, the sequence impedances of the line ($Z_0$, $Z_2$) and of the terminating equipment, as well as the mutual sequence impedances $Z_{01}$ (between the zero- and positive-sequence networks) and $Z_{21}$ (between the negative- and positive-sequence networks) of the line section must be known. Charts for unbalance factors $m_2=Z_{21}/Z_2$ and $m_0=Z_{01}/Z_0$ can be developed from the physical dimensions of the conductors and the line configurations. These factors $m_2$ and $m_0$ make possible the computation of $Z_{21}=m_2Z_2$ and $Z_{01}=m_0Z_0$, because $Z_0$ and $Z_2=Z_1$ always are evaluated since they are used in many other problems of power systems engineering. $Z_0$ and $Z_1$ depend essentially on the geometric mean distance (GMD) between the three conductors and the geometric mean radius (GMR) of the conductors. Figs. 1 and 2 show the values of $Z_0$ and $Z_1=Z_2$ for various sizes of steel reinforced aluminum cable (ACSR) conductors.



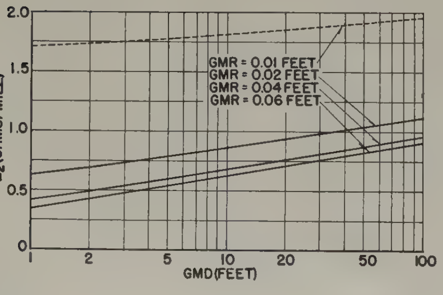
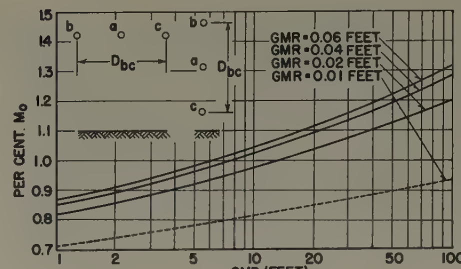




**Fig. 1 (top). Zero-sequence impedance of ACSR conductor lines at 60 cycles. Fig. 2 (bottom). Positive- and negative-sequence impedances of ACSR conductor lines at 60 cycles**



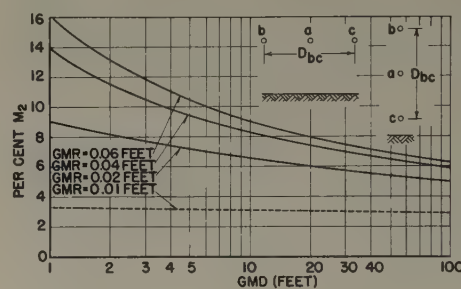




**Fig. 3 (top). Unbalance factor $m_0$ for ACSR conductor lines (60 cycles). Fig. 4 (bottom). Unbalance factor $m_2$ for ACSR conductor lines (60 cycles)**

Figs. 3 and 4 give the values of $m_0$ and $m_2$ for the arrangement of the three conductors on a straight line. The charts show variations of $m_0$ from 0.7 per cent to 1.3 per cent, and of $m_2$ from 16 per cent to 3 per cent. However, for the most frequently used spacings and conductor sizes, a ratio of $m_2$ to $m_0$ equal to 6 is typical. Furthermore, it should be kept in mind that the resultant unbalance ($I_{a0}$, $I_{a2}$) in general is reduced greatly by the balanced terminal equipment on the generator and load sides of the transmission system; in practice $I_{a0}$ and $I_{a2}$ rarely will exceed one per cent of $I_{a1}$. However, each case needs individual attention and the computations are simplified greatly by the use of such charts.

Similar families of curves have been developed for other configurations, thereby eliminating cumbersome computations and making possible a quick estimation of mutual sequence impedances and the analysis of the current unsymmetry expressed by $I_{a0}$ and $I_{a2}$. Ground wires have practically no influence on $m_2$, but their effect on $m_0$ is appreciable and, therefore, it must not be neglected.

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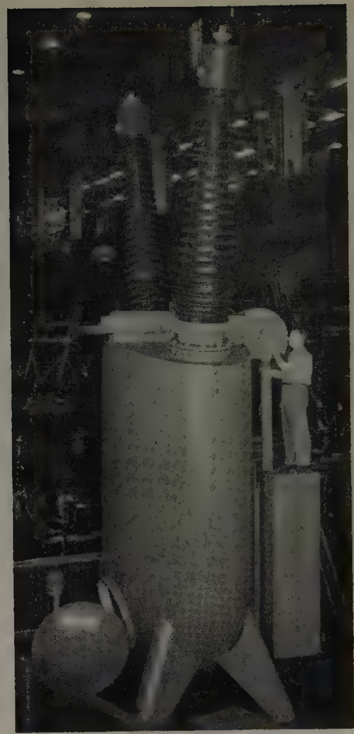
# A New Milestone in Circuit-Breaker Interrupting Capacity 25 Million Kva at 330 Kv



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**With the tremendous loads considered for 330-kv lines, circuit breakers functioning at this voltage are needed with 2,000 amperes continuous current capacity and an interrupting rating of 25 million kva. The description of a breaker's new design, permitting the full interrupting rating to be demonstrated with present test facilities, and its assembly demonstrate how designers and engineers have solved the problems presented by the power companies.**

FIVE YEARS ago development progress was reported on circuit breakers rated 10 million kva at 230 kv.[1,2] Since that time breakers of this rating have been built and installed on 138-kv, 161-kv, and 230-kv systems.[3–5] Instead of this rating proving to be a ceiling, an interrupting capacity of 15 million kva has been considered at 161 kv, 230 kv, and 330 kv. Now the heavy loads being projected for 330-kv lines in this country, particularly the tremendous concentration of electric power at the new Atomic Energy Commission plant near Portsmouth, Ohio, have brought a demand for 330-kv breakers with 2,000 amperes continuous current capacity and the unprecedented interrupting rating of 25 million kva. This article describes one way in which this challenge has been met, and in particular how the high arc-rupturing capacity has made necessary a radically new design which will permit the full interrupting rating to be demonstrated adequately with available High Power Laboratory testing facilities.

## CIRCUIT BREAKER REQUIREMENTS

THE specifications for these large 330-kv circuit breakers contain the following items:

Voltage rating—330 kv—(350 kv maximum)
Insulation level—1,175-kv basic impulse insulation level (BIL) (1,300-kv bushings)
One-minute voltage test—555 kv
Continuous current capacity—1,600 amperes (30 C rise), 2,000 amperes (45 C rise)
Interrupting capacity—44,000 amperes at 330 kv (CO-15 second duty cycle)—46,000 amperes (maximum at reduced voltage)
Momentary current-carrying capacity—69,000 amperes
4-second test—46,000 amperes
Interrupting time—3 cycles at all currents within rating
High-speed reclosing time—15 cycles

The relatively low switching surge magnitudes which are characteristic of modern high-voltage oil circuit breakers, rarely over twice line-to-ground crest voltage, make possible the use of reduced insulation level equipment with considerable savings in the cost of transmission systems. Analogue computer studies[6] indicate that a BIL as low as 1,175 kv is feasible for 330 kv, although the bushings for these breakers have sufficient design margin that the impulse flashover is actually above 1,300 kv. The complete breaker will pass a 555-kv 1-minute 60-cycle voltage test corresponding to the wet 10-second withstand test on 1,300 BIL bushings.

Contrary to the usual expectation of low continuous current-carrying ratings for ultrahigh-voltage breakers, these breakers at times may be required to carry load currents approaching 2,000 amperes, representing one million kw on a single transmission line. Special attention to the contact details was required to provide the requisite thermal capacity and still keep them light enough to travel at the speed necessary for 3-cycle interrupting time.

The title picture shows a view of a single-pole unit of the 330-kv breaker with operating mechanism attached. It would have been possible to use on each pole of the breaker an existing design of pneumatic operating mechanism with 10-inch-diameter cylinder. However, in order to maintain simplicity of operation and positive 3-pole mechanical coupling, a new and much more powerful mechanism with 14-inch-diameter cylinder has been developed especially for this heavy duty. This mechanism shown in Fig. 1, complete with housing, air compressor, and reservoir, is de-

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Full text of paper 54-30, "A New Milestone in Circuit-Breaker Interrupting Capacity 25 Million Kva at 330 Kv" recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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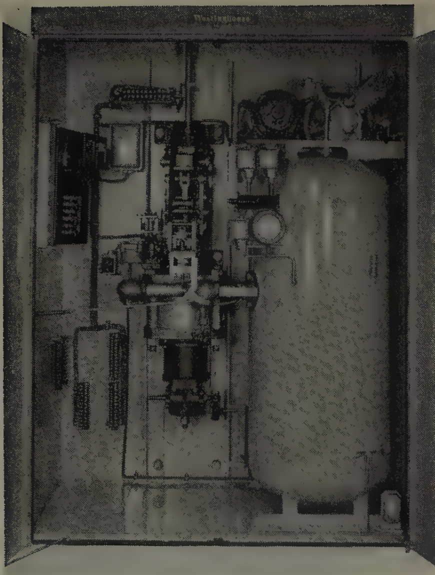


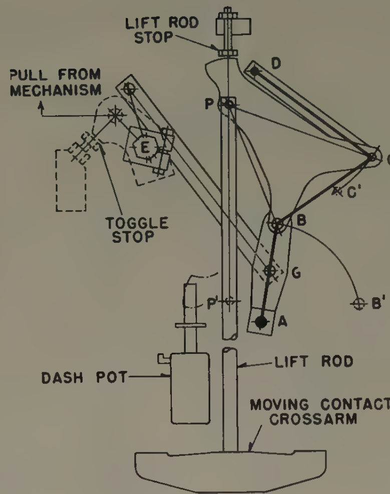


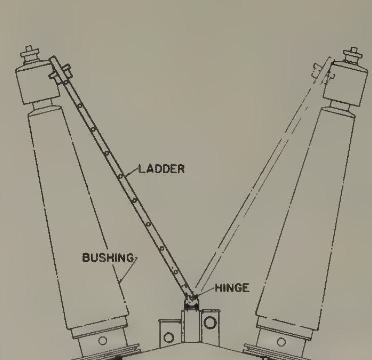

**Fig. 1 (left). The pneumatic mechanism with 14-inch cylinder capable of operating the three poles of the 330-kv circuit breaker simultaneously. Fig. 2 (center). The pole unit mechanism consisting of four bar linkage ABCD and two toggles ABP and EG. The dashpot absorbs the opening shock. Fig. 3 (right). The 330-kv capacitor-type oil-filled bushing with 1,300 BIL insulation**

signed to operate all three poles simultaneously and is described fully by R. C. Van Sickle and R. N. Yeckley.[7] Tests have demonstrated that the breaker and operating mechanism are capable of ultrahigh-speed reclosing in considerably less time than the specified 15-cycle interval.

The 330-kv breaker tank is an extension of the low oil content "Watch-Case" design first introduced for a 230-kv 7,500,000-kva rating in 1949.[8] The tank shape is an elliptic cylinder with hemispherical bottom for reduced oil volume and ability to withstand internal shock pressures incident to the unusually heavy interrupting duty. Because of the very short duration of the arc-quenching process, it has been possible to design for a slight deflection of the tank sides to absorb some of the shock without undergoing permanent deformation. Also, the downward pressure waves are broken up by the hemispherical shape of the tank bottom so that the impact transmitted to the foundations is greatly reduced. Actually the oil volume of 10,500 gallons for three poles is only 40 per cent of that supplied with the 287.5-kv Hoover Dam breakers which were installed in 1936 and were rated only one-tenth of the interrupting capacity of these 330-kv breakers.

Fig. 2 shows a cross section of the pole unit operating levers. This is a double toggle lever system designed for straight-line motion and sufficient mechanical advantage to handle the heavy spring loading required for 3-cycle interrupting time. Liberal use is made of roller bearings to reduce friction and speed up opening time. Included is an oil dashpot-type bumper in each pole unit to cushion the opening stroke. The bumper is provided with a self-filling reservoir which makes it effective whether the tank is full or empty. A gas seal is maintained between pole units, and the operating rods have right-hand and left-hand threads for easy adjustment with positive clamping rod ends to prevent loosening.

The completely oil-impregnated condenser-type bushings, one of which is shown in Fig. 3, have been designed to withstand the shock of interrupting 25,000,000 kva as well as having liberal insulation and current-carrying parts to meet the electrical requirements. A potential tap is provided on each bushing with capacity for 100-watt output on a potential device. The bushing has passed exhaustive electrical and mechanical tests appropriate to the duty imposed. Repeated flashovers, both impulse and 60-cycle,



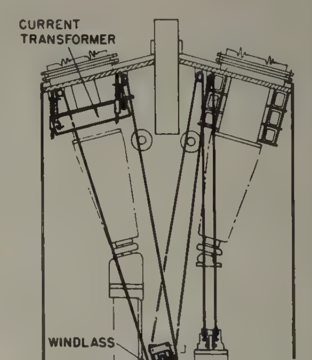




**Fig. 4 (left). The removable scaffold and hinged ladder to facilitate maintenance work on the 330-kv pole unit and terminals. Fig. 5 (right). The hand-crank cable windlass inside tank to assist in installing or removing contact assemblies and current transformers**

were made without internal breakdown. The radio interference at 10 per cent above normal voltage is so low that it cannot be detected above the background level of 55 microvolts at the laboratory, as compared to the proposed industry standard of 2,500 microvolts. In spite of their large size, the 330-kv bushings may be handled in the same manner as smaller bushings; that is, lifted at flange with an auxiliary hitch to the top of the bushing to tilt it at the correct angle for lowering into the breaker.

Provision has been made for as many as three bushing current transformers per terminal—two relaying type and one metering type. Each transformer is imbedded in "Fosterite," which is a durable moisture-resistant, thermosetting plastic compound, and contained in an individual aluminum case. This construction provides adequate cooling and excellent protection against moisture, vibration, and shock during shipment and installation, as well as in service. The secondary leads pass through a compression-type seal in the tank top to maintain the gas seal between poles. These leads are terminated at terminal blocks at the top of each pole unit in order to prevent oil siphoning through the long leads from this point to the terminal blocks inside the pneumatic housing where the desired ratio may be selected.

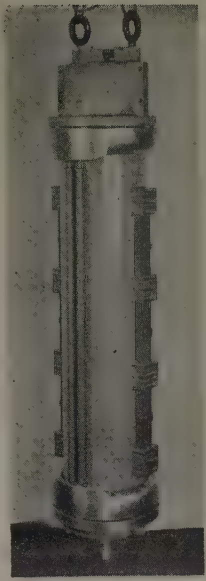
Because of the size and weight of this breaker, several conveniences have been provided for the user's erection and maintenance people in the field, as follows:

1. Scaffold brackets and rail posts to mount outside breaker near top of tank shown in Fig. 4.
2. Ladder and mounting details to get at top of capacitor bushing, also illustrated in Fig. 4.
3. Platforms to mount inside tanks at a convenient working height for inspecting and adjusting interrupters.
4. Windlass hoist inside pole unit for lifting interrupters into place. Current transformers are shipped assembled in breakers, but the windlass hoist may be used later for adding or removing transformers without removing the capacitor bushings by using a special lifting tray provided. The way in which both of these operations are performed can be seen in Fig. 5.

## INTERRUPTERS

The heart of a high-power circuit breaker is the interrupting device which makes possible quenching of the arc drawn by the separating contacts in a minimum of time and with a minimum of disturbance. The multiflow principle of arc extinction has been demonstrated to be so effective that high-voltage breakers rated as high as 330 kv can be built with only two interrupting gaps per pole. However, the limitations of High Power Laboratory facilities make the testing of breakers rated more than 10 million kva a matter of doubtful extrapolation unless subdivisions smaller than a half of a pole unit can be given separate tests.

The interrupter assembly shown in Fig. 6 represents a radically new design with four independent arc-rupturing units assembled in an insulating tube for simultaneous operation. A spring-driven oil pump at the top of the assembly, as indicated in the section view of Fig. 7, provides oil flow to each break for the interruption of line-charging currents



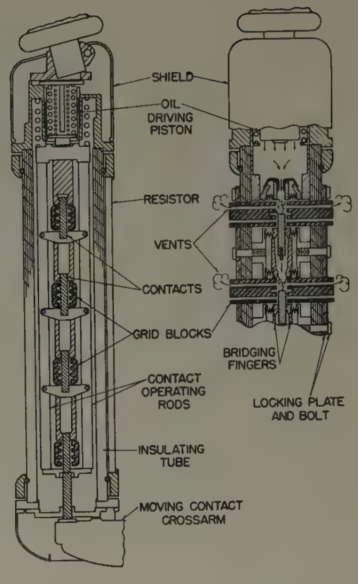



**Fig. 6 (left). The tubular 4-break interrupter assembly for one terminal of the 330-kv breaker. The small tubes contain resistance elements for improving the voltage distribution. Fig. 7 (right). Section view of 4-break interrupter assembly showing oil driving piston, flow-guiding fiber grid blocks, moving contacts, and bridging fingers**

without arc restriking. Also, this pump performs a flushing action immediately following each fault interruption, clearing out all gas and other arc products to prepare for another operation within a fraction of a second if required.

A special feature is the removable laminated and cemented fiber block which guides the oil flow in the arcing region of each contact gap and provides the exhaust vent

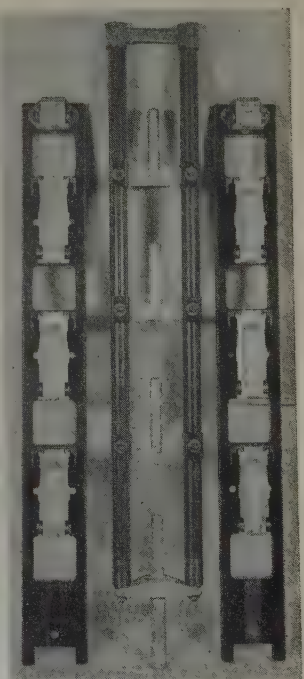


**Fig. 8 (left). The removable laminated and cemented fiber grid blocks which permit inspection of contacts without disturbing interrupter alignment. Fig. 9 (right). The bridging finger and moving contact subassemblies removed from the interrupter**

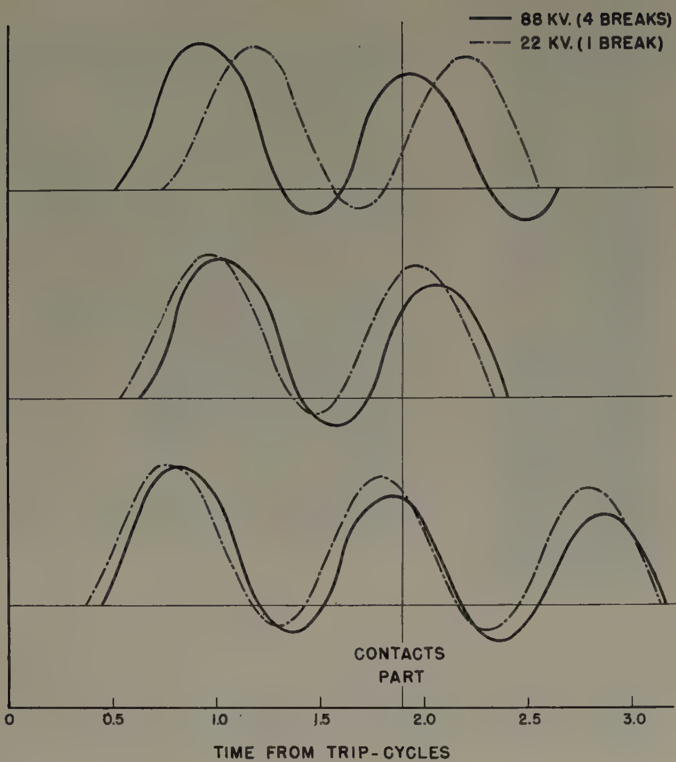



**Fig. 10. Comparison of interrupter performance at 88 kv on 4 breaks with 22 kv on 1 break. Opening 13,000 to 15,000 amperes under various timer settings. Effectiveness of voltage distribution is indicated by similarity of arc duration**

channels. Sufficient oil storage is provided close to the arc to produce self-generated deionizing action for high-current interruption. When any one of the blocks is withdrawn as shown in Fig. 8, the contacts can be inspected and observed while being opened or closed. If further disassembly is desired for replacement or maintenance, the removal of a few screws allows the bottom casting to be taken off and the moving and stationary contact subassemblies drawn out as shown in Fig. 9. In no case is it necessary to disturb the alignment of the tube and piston assembly.

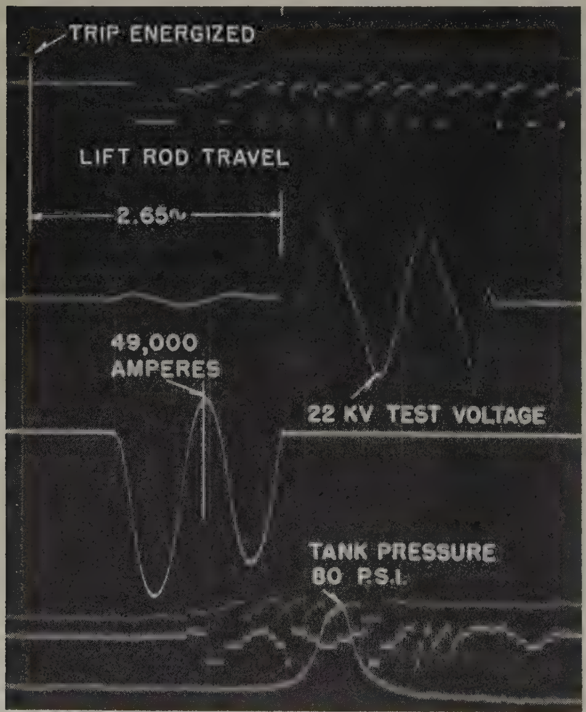



**Fig. 11. Oscillogram of 49,000-ampere interruption on 4 breaks to verify mechanical strength of interrupting assembly**

Proper contact adjustment is obtained automatically in the closed position of the breaker merely by the correct positioning of the moving contact crossarm bridging the contact assemblies in the closed position of the breaker. The heavy-duty silver-plated finger contacts with arc-resisting silver-tungsten surfaces provide long life and adequate current-carrying ability to meet a 2,000-ampere continuous rating. Heat transfer is assisted by convection oil flow, entering the check valve at the bottom and out the valve at the top of the tubular assembly.

Voltage-grading resistors parallel the interrupter assemblies on each terminal to assist in equalizing the division of voltage during arc interruption. The carbon-impregnated blocks making up these resistors are of the same type used successfully for many years in arresters and circuit breakers. The small residual resistor current of unity power factor is easily interrupted in the isolating gap drawn below the interrupter as the moving contact crossarm drops to the full open position.

## VERIFICATION OF 25-MILLION-KVA RATING

A FULL-SCALE test to demonstrate a 3-phase interrupting capacity of 25 million kva at 330 kv is obviously out of the question in any high-power laboratory of practical size. However, the unit test method whereby a subdivision of the breaker is tested to full rated current-interrupting capacity at its proportionate fraction of the rated voltage is recognized as a reasonable approach to the demonstration of the arc-rupturing ability of the breaker. For instance, a test of one million kva on 1/24 of the complete breaker (one of eight duplicate units in one of the three poles) will apply approximately the same stress which this unit would experience during a 24-million-kva grounded short circuit on the complete breaker.

Evidence of good voltage distribution between contact breaks is shown by the uniformity of interrupting action whether operating at 22 kv on one break or at 88 kv on four breaks as illustrated by Fig. 10. Three interruptions of approximately the same current are shown for each condition with different timing of contact parting relative to the short-circuit current wave. The arcing time range is evidently almost exactly the same for either one or four breaks.

A unit fractional-pole test, however, does not demonstrate the full internal shock pressure in either an assembly of units on one terminal or a pair of assemblies in one tank. Fortunately, the normal arcing time is so short in these modern high-speed breakers that there is very little difference as the applied voltage is reduced, particularly when the same rate of rise of recovery voltage is maintained. Thus, after the ability of a single unit to handle its share of the interrupting duty has been demonstrated, a test at full current-interrupting capacity in one assembly of four units, or a complete breaker pole, even at a fraction of rated voltage, is used to develop practically full arc energy and shock pressure and

thus demonstrates mechanical adequacy of the tanks, bushings, and interrupting assemblies.

Table I gives data from single-phase tests made at 154, 132, 88, 44, and 22 kv to the full capacity of the laboratory on a half-pole unit of four breaks. With a line-to-line operating voltage of 330 kv, each half of the pole unit normally handles 95 kv. At 22 kv, the interrupted current was carried above the maximum interrupting rating to 49,000 amperes as shown in the oscillogram of Fig. 11 to demonstrate the strength of the insulating tube and interrupter assembly. The tests listed in Table II at 66, 44, and 22 kv on a single unit, which is normally subjected to about 25 kv, show clearly the ability of the interrupter design to handle extra voltage as well as currents of 44,000 amperes or more corresponding to the rating of 25 million kva on a 3-phase basis. It can be seen also that the arcing time for a given current is very nearly the same over a wide range of applied voltage so that the 4-break tests at less than normal voltage still have approximately the same arcing time and energy as if full rated voltage were available.

One other question arises concerning the insulation between live parts and tank during the time when the gas bubbles are passing from the interrupter vents to the surface of the oil. The diagram of Fig. 12 shows the way in which this point was checked by using one transformer to bias the

**Table I. High-Power Laboratory Interrupting Tests; Single-Phase Tests on Half Pole (Four Breaks)**

| Test Voltage Kv | Interrupted Current RMS Amperes | Interrupting Time-Cycles | Per Cent Rated Current Interrupting Capacity |
|---|---|---|---|
| 154 | 1,070 | 3.15 | 2 |
| 154 | 2,500 | 3.1 | 6 |
| 154 | 4,600 | 3.05 | 10 |
| 154 | 6,000 | 3.0 | 15 |
| 132 | 1,070 | 2.9 | 2 |
| 132 | 2,100 | 3.0 | 5 |
| 132 | 7,100 | 2.9 | 17 |
| 132 | 7,100 | 3.05 | 17 |
| 88 | 13,800 | 2.65 | 31 |
| 88 | 13,700 | 2.4 | 31 |
| 88 | 15,000 | 3.0 | 34 |
| 88 | 15,300 | 2.5 | 35 |
| 44 | 27,400 | 2.55 | 62 |
| 44 | 29,500 | 2.55 | 67 |
| 44 | 29,500 | 2.4 | 67 |
| 44 | 30,600 | 2.75 | 70 |
| 22 | 42,000 | 2.7 | 96 |
| 22 | 46,000 | 2.6 | 104 |
| 22 | 46,000 | 2.5 | 104 |
| 22 | 49,000 | 2.65 | 111 |

**Table II. High-Power Laboratory Interrupting Tests; Single-Phase Tests on 1/8 Pole (One Break)**

| Test Voltage Kv | Interrupted Current RMS Amperes | Interrupting Time-Cycles | Per Cent Rated Current Interrupting Capacity |
|---|---|---|---|
| 66 | 480 | 2.8 | 1 |
| 66 | 2,500 | 3.0 | 6 |
| 66 | 15,000 | 3.0 | 34 |
| 66 | 20,800 | 2.8 | 47 |
| 44 | 720 | 2.7 | 2 |
| 44 | 2,000 | 2.8 | 5 |
| 44 | 10,000 | 3.0 | 23 |
| 44 | 22,500 | 3.0 | 51 |
| 22 | 41,000 | 2.8 | 93 |
| 22 | 40,000 | 2.8 | 91 |
| 22 | 41,600 | 2.5 | 95 |
| 22 | 48,000 | 2.75 | 109 |

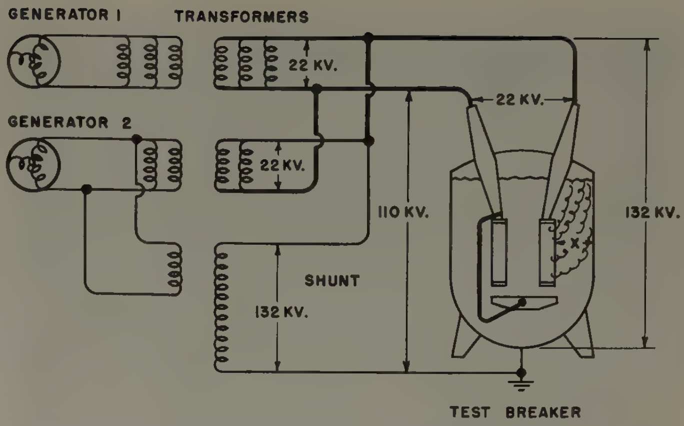



**Fig. 12. Schematic of special test connections to increase voltage to tank at point X to demonstrate insulation strength during high-power interrupting test**

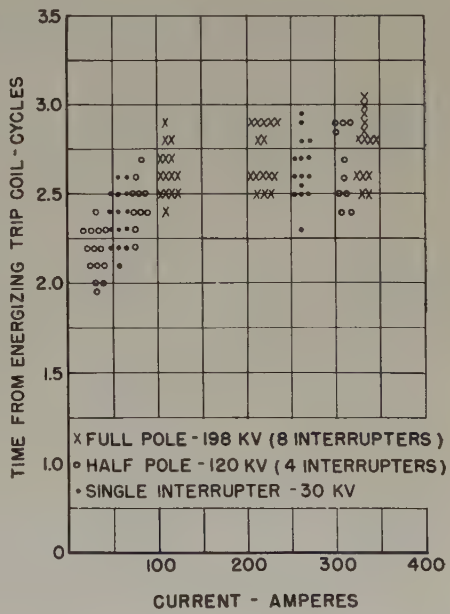
22-kv test circuit at 132 kv above ground. A heavy short-circuit current of 35,000 amperes was applied to one assembly of four breaks in series and a voltage gradient of 132 kv maintained between live parts and ground for several seconds without any evidence of insulation weakness.

Adequacy of the contact design has been verified by momentary current tests to 73,500 amperes, 6 per cent above the specified rating, and also a 4-second test at 46,000 amperes.

The life of the contacts of such a large high-voltage circuit breaker is of importance to the men who maintain the equipment. The exceptionally high rupturing capacity of this 330-kv breaker would lead one to expect little more than two interruptions at full rating without need for contact maintenance. However, one set of contacts has been used to interrupt not only two short-circuit currents in excess of the breaker rating but a large number of additional tests of various current values giving an integrated total of approximately six times the rating.

The orifices of the interrupting unit are only slightly enlarged after such heavy duty so that further tests still can

**Fig. 13. Chart of restrike-free charging interruptions by single break, 4 breaks, and 8 breaks over current range up to 330 amperes**



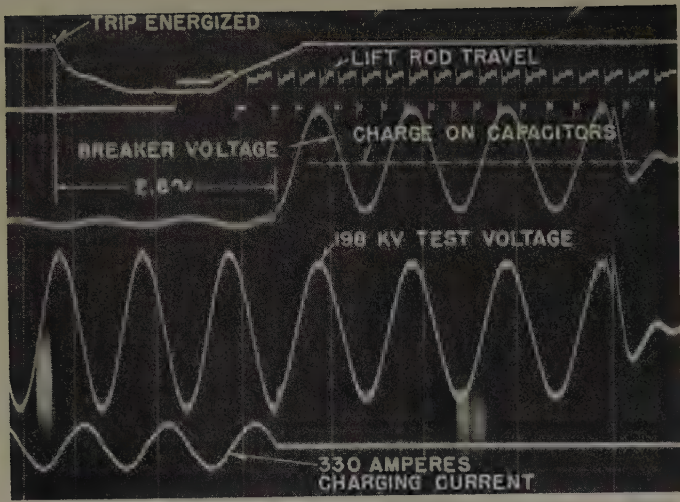



**Fig. 14. Oscillogram of charging current interruption without restrike of 330 amperes at 198 kv, corresponding to over 300 miles of 330-kv transmission line**

be made without replacement. Furthermore, the block assembly is symmetrically designed so that it can be taken out and reinserted after being turned over so as to bring the unburned orifices into the arcing area and thus double the life of the unit.

## FACTOR-OF-SAFETY INTERRUPTING TESTS

TRANSMISSION-LINE circuit breakers interconnecting large systems sometimes may be subjected to out-of-phase conditions at the moment of tripping which will produce recovery voltages as high as twice normal line-to-ground potential across each pole of the breaker. Because of line impedance, the current to be interrupted in most cases is only 10 to 20 per cent of the current-interrupting capacity. Table III shows the exceptional interrupting ability of this breaker in that currents up to 3,750 amperes at 396 kv across a single pole and up to 4,600 amperes at 198 kv across a half pole have been cleared with an interrupting time averaging only slightly over 3 cycles. The highest current of 4,600 amperes represents a current of 10 per cent of rated current-interrupting capacity at a voltage of more than twice normal for a 330-kv system.

**Table III. High-Power Laboratory Interrupting Tests; Double-Voltage Tests on Full Pole (Eight Breaks) and Half Pole (Four Breaks)**

| Number of Breaks | Test Voltage Kv | Interrupted Current RMS Amperes | Interrupting Time-Cycles | Per Cent Rated Current Interrupting Capacity |
|---|---|---|---|---|
| 8 | 396 | 500 | 2.7 | 1 |
| 8 | 396 | 1000 | 3.2 | 2 |
| 8 | 396 | 2500 | 3.2 | 6 |
| 8 | 396 | 2500 | 3.2 | 6 |
| 8 | 396 | 2500 | 3.3 | 6 |
| 8 | 396 | 3750 | 3.6 | 9 |
| 4 | 198 | 1120 | 3.15 | 2 |
| 4 | 198 | 1170 | 3.4 | 2 |
| 4 | 198 | 1120 | 3.0 | 2 |
| 4 | 198 | 2600 | 3.15 | 6 |
| 4 | 198 | 2750 | 3.4 | 6 |
| 4 | 198 | 2500 | 3.0 | 6 |
| 4 | 198 | 4600 | 3.15 | 12 |

Also note 66-kv tests on one break in Table II.

Another critical operating characteristic is the performance when switching transmission-line charging current. It is important to avoid hazardous switching surges by not permitting more than one restrike (defined as an arc reignition after a current pause of 1/4 cycle or more). One pole of a 330-kv breaker has been tested, switching a large capacitor bank[9] at a voltage of 198 kv, the actual line-to-neutral voltage for a 345-kv line voltage, with currents as high as 330 amperes. No restrikes were obtained in a group of some 45 tests over a wide current range under the control of a synchronous timer which tripped the test breaker so as to part contacts at a succession of predetermined intervals 1/10 cycle apart relative to a current zero. These test results, together with similar charging current interruptions with 30 kv on one unit and 120 kv on four units, are tabulated in curve form in Fig. 13, and a typical oscillogram is shown in Fig. 14 for a 330-ampere test at 198 kv.

## CONCLUSIONS

1. A 330-kv breaker of 25 million kva interrupting capacity using a tank shape requiring relatively low oil volume has been designed and tested to its full rating by means of the generally accepted unit test method.

2. Full-voltage charging-current tests to currents equivalent to more than 300 miles of 330-kv transmission line have been made with restrike-free performance.

3. A single pneumatic mechanism for operating all three poles of the breaker has been shown to be capable of handling the load requirements of the breaker and also to operate on high-speed reclosing duty with reclosing intervals appreciably less than 15 cycles.

4. Multibreak interrupters with contacts readily accessible for inspection have proved adequate for repeated duty at high power and to meet all momentary and continuous rating requirements.

A completely new circuit breaker of the strong and safe dead-tank type, suitable for even earthquake conditions, has been provided with completely tested components which are simple to install, adjust, and maintain. Once again the steel tank oil circuit breaker has met the challenge of this new milestone in voltage rating and short-circuit interrupting capacity.

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# Magamp Regulator Tests and Operating Experience

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THE FIRST INSTALLATION of the Magamp regulator and excitation system on a turbine generator was placed in service in the Springdale Station of the West Penn Power Company on April 1, 1953. The machine to which it was applied is a 50,000-kw 3,600-rpm hydrogen-cooled topping unit. Performance tests were conducted on the unit on July 19, 1953. The purpose of this digest is to present the operating experience and the results of the tests.

The Springdale Station was selected because it is exposed to violent system voltage swings created by the fluctuations of a steel-mill arc-furnace load in the vicinity, making it possible to observe the action of the regulator under normal load conditions. The magnetic amplifier regulator was applied on unit number *6* which is closely connected to the 132-kv bus and radial line supplying the steel mill load.

The Magamp regulator and excitation system utilizes a direct-connected buck-boost exciter, the principal source of excitation being a self-excited shunt field. Buck and boost ampere-turns are supplied from a power Magamp through separate exciter control fields. Intelligence taken from potential and current transformers at the machine terminals is fed through compensation and limit circuits and compared with a reference. The resulting difference, or error signal, is amplified by an input Magamp and used to control the power Magamp. The a-c supply for the regulator is a direct-connected 420-cycle permanent-magnet generator.

Performance tests were conducted to determine regulator operation during load dropping and normal load conditions while supplying the steel mill load. Tests were made also to verify the operation of the minimum excitation limit and to determine the excitation system response ratio.

Because the present definition of exciter response ratio was written with the rheostatic regulator definitely in mind certain ambiguities arrive in applying this definition directly to dynamic regulators. Several methods of testing for response ratio exist that come within the wording of the definition. Some methods give a figure of response ratio which is a function of exciter and self-excited field rheostat only and do not give any indication of the ability of the regulator and pilot exciter to force.

The oscillograph record of the response ratio test is shown in Fig. 1. The response ratio determined from the oscillogram is 1.63. The method used in this test provides a measure of the response of exciter and rheostat, pilot and regulator, and damping means. The only concession to expediency is that the test is made at no load. A regulating loop is made up consisting of the pilot, regulator, and exciter. The exciter voltage is adjusted to the nominal collector-ring voltage. A switch is opened breaking the regulating loop and causing the regulator to force upward. The magnitude of the regulator control signal is such that

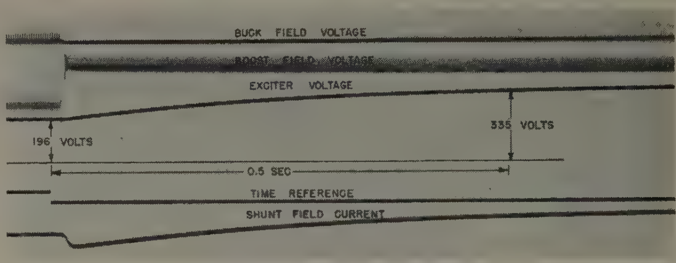


**Fig. 1. Response ratio test**

full output of the regulator is obtained. The exciter voltage is recorded during the next 1/2 second and the response ratio is computed in the same manner as it would be for a rheostatically controlled exciter. Damping connections are included and the adjustments are the same as would be used in operation of the complete excitation system.

The operating experience with the Magamp regulator has been excellent. Because of factory preadjustments and a final simulator check of the damping adjustments made at the time of installation the regulator was placed in service with minimum effort and delay. The ease of placing the excitation system under control of the regulator appeals favorably to the operating personnel.

The normal load and load dropping tests show that the Magamp regulator and excitation system has the following characteristics:

1. Extremely fast acting in response to terminal voltage variations.
2. Capable of supplying megavars with rapid response to varying system requirements.
3. Very stable and well damped.

The minimum excitation limit test verifies the following:

1. Theory of operation of the limit circuits.
2. Accuracy of calibration.
3. Sharp transition into and out of limit operation.
4. Stable operation.

The response ratio test procedure used is a practical method for obtaining excitation system response ratio. The response ratio of 1.63 obtained on this unit should not be considered indicative of the requirements of excitation systems in general.

Digest of paper **54-41,** "Magamp Regulator Tests and Operating Experience on West Penn Power System," recommended by the AIEE Committee on Power Generation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems,* 1954.

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# Oil Circuit Breaker for Switching Capacitors


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LARGE BANKS of high-voltage capacitors are being used to an increasing extent for voltage regulation and reactive power generation. Recent experience switching 30,000 reactive kilovolt-amperes in two parallel banks at 115 kv on the Bonneville Power System has indicated the special nature of the switching problems associated with the use of oil circuit breakers for energizing and de-energizing such large capacitances.

It has become evident that not all types of circuit breakers will give satisfactory service in controlling the magnitude of switching surges and in particular limiting the high-frequency current surges exchanged between parallel banks with negligible reactance between them. However, certain oil circuit breaker designs can be modified suitably to provide satisfactory operation when switching high-voltage capacitor banks.

Two standard 115-kv oil circuit breakers are shown in Fig. 1 with the 15,000-kva capacitor banks to which they are connected at the Walla Walla (Wash.) Station on the Bonneville Power System. Each pole of these 3,500-megavolt-ampere 3-cycle breakers was provided with a pair of multiflow De-ion grid interrupters, consisting of one pressure-generating break, one interrupting break, and a spring-driven oil piston which is necessary to provide positive arc-quenching action when de-energizing the capacitor bank.

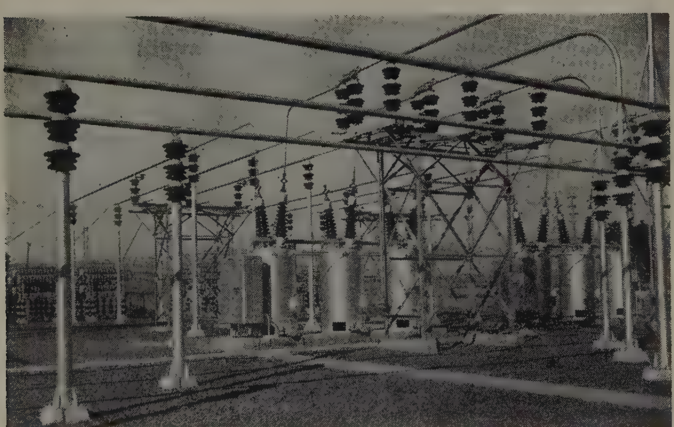

**Fig. 1. Two standard 115-kv oil circuit breakers with the 15,000-kva capacitor banks to which they are connected at the Walla Walla Station on the Bonneville Power System showing a portion of the bus work and the capacitor-switching oil circuit breakers, with the capacitor banks in the background**

Initial switching tests at the time of installation of the breakers showed no arc restriking, a restrike being defined as a reignition of the arc after a current pause of 1/4 cycle or more. However, inspection of the interrupters after 10 months of service and some 350 operations per circuit breaker indicated that severe pressure shocks had been experienced.

This was attributed to large-magnitude transient currents of high-frequency surging between the two parallel capacitor banks during occasional restrikes in a breaker de-energizing one bank while the other was still energized on the bus. Calculations and oscillograph measurements indicated that these high-frequency surges had a crest value of at least 15,000 amperes at a frequency of 12,000 cycles per second.

Similar surges were reproduced in a high-power laboratory by means of a special test circuit, and modifications of the interrupter assembly were made to cushion the shocks by providing an enclosed gas chamber near the arc and also to reinforce those critical items that appeared to have been overstressed.

Suitable springs on the tie rods holding the plate structure together were arranged to permit opening up of the stack as an overpressure relief valve.

The oil-driving piston of the multiflow interrupters has a delayed action so that attempts to extinguish the arc will not be made until sufficient contact separation is available to hold the recovery voltage without restriking. With the proper adjustment of this delay feature it was found that arc restriking could be eliminated almost completely from the interrupters.

Another approach to the improvement of capacitor switching performance is the use of resistors paralleling the interrupting assemblies on each breaker terminal. Laboratory tests with 1,320 ohms per pole, or 1.5 times the capacitive reactance per phase of a 15,000-kva bank, showed no restriking on parallel bank tests even with the test voltage raised to 88 kv across a single pole or 33 per cent above normal line-to-neutral voltage. As an added factor of safety, these resistors were installed in the breakers at Walla Walla, and switching tests made under conditions of the parallel bank on or off the bus and with the neutral of the switched group either grounded or ungrounded. There were no restrikes between the main contacts on any test and such arc reignitions as did occur during the disconnection of the resistor produced no oscillations since the series resistance-capacitance circuit was overdamped.

It has been demonstrated that the dependable oil circuit breaker with appropriate modifications can be used to switch large 115-kv shunt capacitors satisfactorily even under the most severe service conditions.


Digest of paper 53-348, "Oil Circuit Breaker for Switching 115-Kv Shunt Capacitors," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Published in AIEE *Power Apparatus and Systems*, October 1953, pp. 1066–72.



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# Flow of Energy in Synchronous Machines

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A STUDY OF THE flow of electromagnetic energy in a typical, somewhat idealized 3-phase alternator is carried out on the basis of the electromagnetic field analysis with the objective of a better understanding of synchronous machines from an educational and analytical standpoint, and in the hope that it may be of value in design. This article constitutes a sequel to a previous similar study of d-c machines.[1] Relatively few authors have considered problems in electric machinery on this basis.[2–4]

A modified Poynting's Vector to describe the flow of energy is developed and its employment justified. The modification consists of disregarding certain components which lead to an irrelevant, apparently circulatory flow of energy. The electromagnetic field in the air gap of a cylindrical rotor alternator is first derived, assuming sinusoidal space variation for the revolving magnetic field of the rotor, and taking into account the exact shape of the stator mmf wave produced by currents in the assumed numerous, closely spaced phase-belt conductors. This gives rise to a trapezoidal space distribution of the stator magnetic field intensity, and is in contrast with the conventional treatment which employs only its fundamental sinusoidal component.

The energy flow vectors for any load are resolved into active and reactive components, which then are derived from the developed **E** and **H** fields in the gap. The active components describe a flow of energy, accounting for the net power output of the machine, that emerges upward from the rotor into the gap, then proceeds axially in the gap, until it eventually is directed toward the output leads of the machine. The result is sketched in Fig. 1 for the region of the gap. This flow of energy is described quantitatively in the gap where the analytic expressions for the space-dependent components of the flow vectors are derived (both the instantaneous and the time-average components), and qualitatively in the remaining regions of the machine.

The reactive components describe a flow of energy which is entirely circulatory, emerging from the rotor in one-half of each phase-belt region and re-entering the rotor in the remaining half-space. An analysis of this flow of energy, similar to that for the active components, is developed and a sketch of the resultant flow of reactive energy in the gap is shown on Fig. 2.

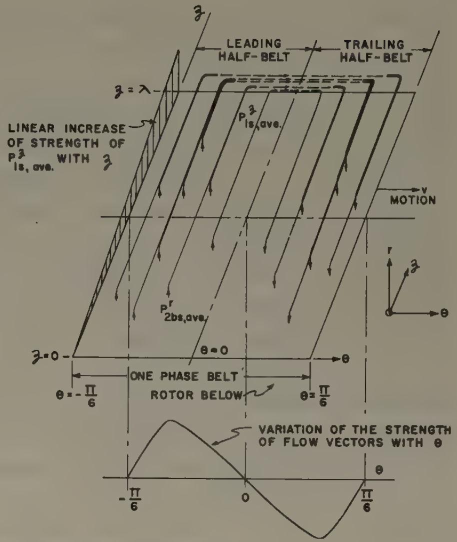


**Fig. 2. Net flow of reactive energy in the gap**

In addition, the flow of energy from the gap to the stator conductors is described quantitatively showing that the electromagnetic energy enters the stator conductors only to be redirected back into the gap, except for the small modification required to supply conductor losses. The conductors merely serve to guide the flow of energy by the contribution which they make to the over-all **E** and **H** fields in the surrounding space. It is shown also that for practical machines any variation in the developed energy flow vectors with the radial co-ordinate in the gap is of negligible significance. The major limitation of the analysis is the assumed condition of linearity, since saturation and hysteresis effects have been neglected. Consequently, this study may be regarded as an approximate, first-order description of the flow of energy in a practical alternator, or synchronous motor, to which it equally well applies.

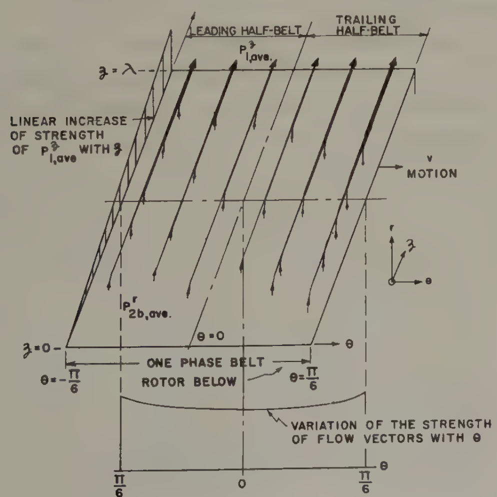


**Fig. 1. Net flow of active energy in the gap**

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Digest of paper 54-109, "Flow of Energy in Synchronous Machines," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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# A 330-Kv 15,000-Mva Steel-Clad Impulse Breaker

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POWER CIRCUIT BREAKERS now are being installed on the first 330-kv power lines in the United States. This initial use will be at the Muskingum River plant of the Ohio Power Company, an operating company of the American Gas and Electric Company system.

These 330-kv circuit breakers have been designed and tested for a service requirement that involved some new factors in combination with many old ones. In addition to the higher operating voltage, the interrupting and continuous current ratings exceeded existing standards. These new requirements had to be met in addition to the generally accepted standards for short interrupting times, fast reclosing times, minimum oil and contact deterioration, long life, trouble-free performance, ease of installation and maintenance, and performance as demonstrated by breakers already in production.

As early as 1946 engineering studies were started on a 360-kv low-oil-content circuit breaker for the Tidd 500-kv Test Project. Such a breaker was built and met the specified characteristics.

In the meantime, demands developed for high-capacity breakers at all voltages from 138 kv to 330 kv. These requirements resulted in a change of viewpoint and it became evident that a more conventional tank-type breaker would meet the needs of the industry better.

These first 330-kv steel-clad impulse breakers were built for an interrupting rating of 15,000 megavolt-amperes (mva), a continuous current rating of 1,600 amperes, an interrupting time of 3 cycles, and a reclosing time of 20 cycles. The conventional arrangement of high-voltage tank-type breakers was followed, except that each pole unit has its own operator. The specially shaped tanks reduced oil requirements as well as the physical size and weight. The bushings and operators have similar designs to those used on the other high-capacity circuit breakers.

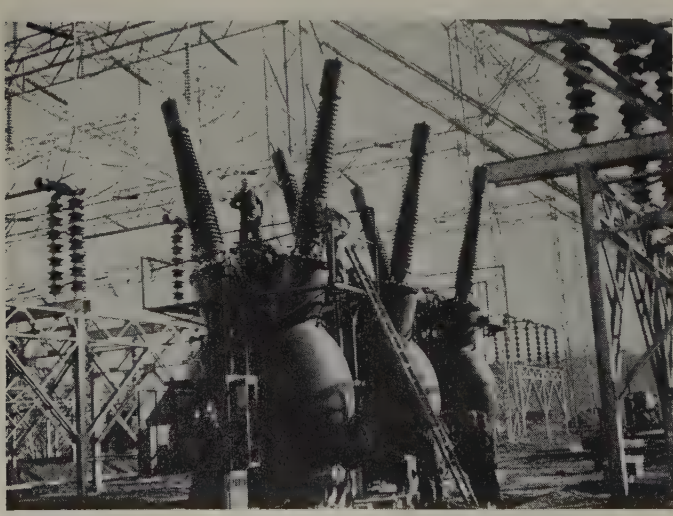

Fig. 1. Installation of the first 330-kv breaker

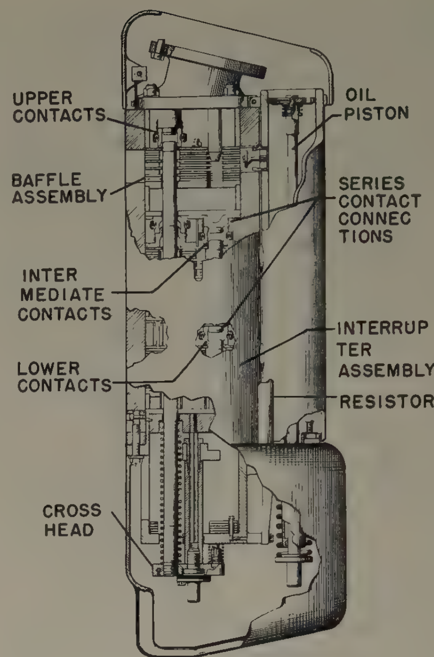


**Fig. 2. Sectional view of the 330-kv impulse interrupter showing the three simultaneously operating series breaks, laminated insulation structures for directed oil flow, and the auxiliary oil piston**

The interrupter followed the design plan used for those of the high-capacity 138-, 161-, and 230-kv breakers. This plan utilized a basic contact unit arrangement capable of compounding for various voltage requirements. The three sets of interrupting and current-carrying contacts for each interrupter are housed in an insulation tube assembly, and an auxiliary oil piston is provided to aid in the interruption of low values of capacitive and inductive currents.

The fullest use has been made of modern up-to-date test facilities to prove these breakers. Many parts of this test program are believed to be more severe than operating experience will prove necessary. Extensive use was made of the new Switchgear High Power Development Laboratory for current switching and interrupting tests.

As is well known by this time further extension of the 330-kv power transmission in the Ohio Valley will require breakers with a higher interrupting rating than the first breakers will have. The favorable experience with these 15,000-mva breakers indicates that there are relatively few new problems involved in the development of the 25,000-mva rated breakers because many of the components already have been proved.

Digest of paper 54-59, "A 330-Kv 15,000-Mva Steel-Clad Impulse Breaker to Guard the Nation's First 330-Kv Lines," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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# Thermocouple-Type Ammeters for Use at Very High Frequencies

O. G. McANINCH
MEMBER AIEE

**The measurement of currents at the higher frequencies is made difficult by the increased inductances and capacitances inherent in measuring equipment used for low-frequency alternating currents. Here are presented the theory, construction, and performance of a wide-frequency-range ammeter with excellent characteristics in the vhf band.**

THE MEASUREMENT of currents at higher frequencies is complicated by the ever-magnified inductances and capacitances associated with the measuring equipment. On direct currents, permanent-magnet moving-coil instruments are used extensively, and here the main consideration is the series resistance of the instrument. Instruments for lower frequency alternating currents generally make use of the electrodynamic or some form of moving-iron measuring system. Here again the series resistance of the instrument is important, but in addition, the series inductance of the necessary coils becomes a factor. As the frequency is increased the effects of the inductance increase, and in the middle audio frequencies, these effects become formidable.

This article reviews problems encountered in the measurement of current at the higher frequencies, and discusses the performance of ammeters tested in the very-high-frequency range. It also presents the theory, construction, and performance of an experimental, wide-frequency-range ammeter having superior characteristics in the very-high-frequency band.

## INSTRUMENTS FOR MODERATELY HIGH FREQUENCIES

IN THE LOWER r-f range, various thermal conversion devices have been developed for current measurement. In these instruments the current flowing produces heat, and the resulting temperature effect is used as a measure of current magnitude. By this means the coils of wire, with their associated high inductance, are eliminated from the a-c circuit, and it is possible to produce measurable temperatures, in simple heater wires, without bothersome high resistances.

The most satisfactory of these thermal converters is the thermocouple type. Basically (Fig. 1) this simply consists of a short length of wire through which the current to be measured is led. A thermocouple junction is secured to the center of the heater wire and measures the temperature rise produced by the current flow. This unit is the primary detector of the high-frequency current, and operates in conjunction with a sensitive d-c millivoltmeter which is the end device and indicates the high-frequency current in terms of the thermocouple output. Fig. 2 pictures a typical thermocouple converter of this type, which has been provided with cold junction thermal compensation to maintain a stable reference temperature for the thermocouple.[1]

This converter is usable from direct current up into the r-f range with good accuracy, and without bothersome high resistance and inductance factors to upset measurements.

## PROBLEMS OF MEASURING AT HIGHER FREQUENCIES

STILL FURTHER increases in the frequency range, however, have made it evident that this thermal converter, too, has its limitations. Mainly these are of two types. The first is the well-known "skin effect," while the second is the old problem of increased impedance effects.

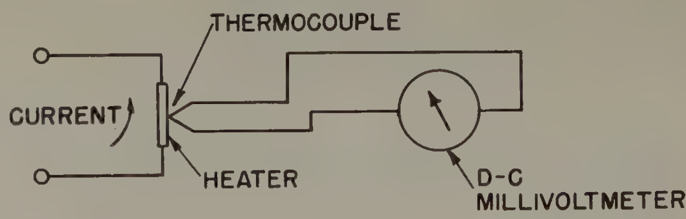


**Fig. 1. Schematic diagram of elementary thermocouple a-c ammeter**

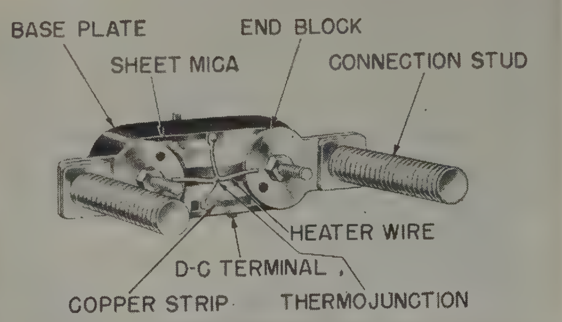


**Fig. 2. A conventional thermocouple for an r-f instrument**

Full text of paper **54-170,** "Thermocouple-Type Ammeters for Use at Very High Frequencies," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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The author wishes to acknowledge the contributions of his associates, particularly those of T. A. Rich, H. R. Meahl, and P. C. Michel of the company's General Engineering Laboratory, who were primarily responsible for the early development work on low-impedance thermocouple ammeters.

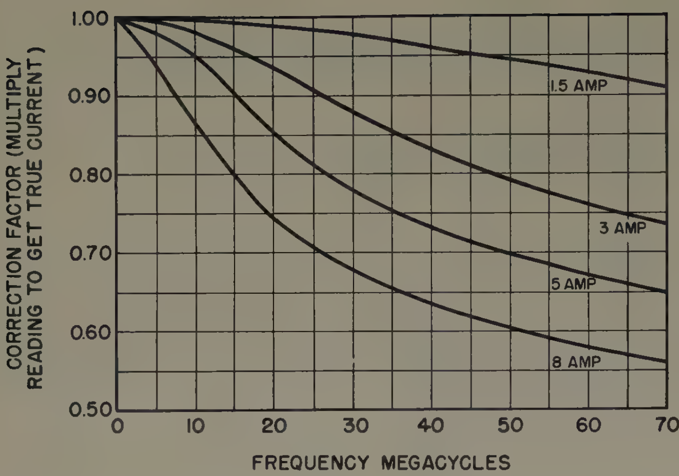


**Fig. 3. Correction-factor curves for conventional thermocouple ammeters which are based on skin-effect calculations**

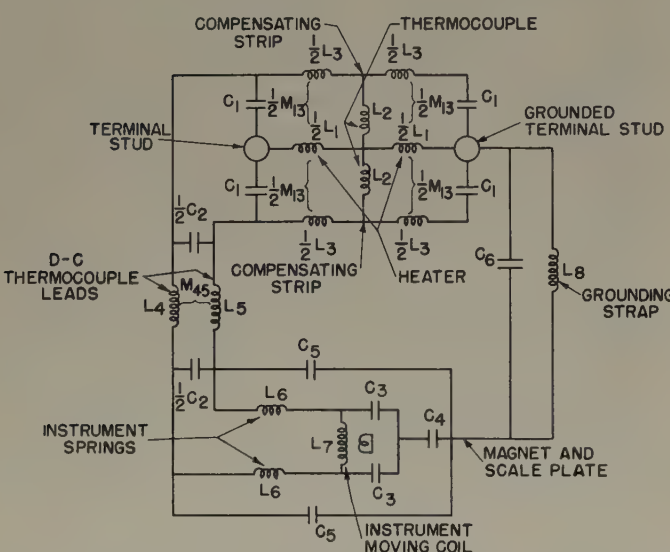


**Fig. 4. The internal circuit of conventional thermocouple ammeter at high frequencies**

Skin effect, the phenomenon of nonuniform current distribution in conductors at high frequencies, causes the heater resistance to increase with increased frequency. This increases the heating for a given current level, and causes the instrument to read high. Hence it becomes necessary to apply a multiplying factor to correct instrument readings, and this factor varies with frequency. Some representative correction factor curves, based on skin-effect computations,[2] are shown in Fig. 3. As can be noted from these curves, the correction is greater for instruments of higher current ratings, since the change in resistance occasioned by skin effect is greater in their larger size heater wires. In certain commercially available instruments the solid heater wire has been replaced by a thin walled tubular heater, which serves to reduce skin-effect errors substantially.

The other of the previously mentioned problems, impedance effect, results from inductances and capacitances associated with the converter which are negligible at low radio frequencies. Effectively, at higher frequencies, there is associated with the heater wire both a series inductance and a shunt capacitance. For example, a typical converter having a d-c resistance of the order of 0.03 ohm may have an impedance of the order of 60 or 70 ohms at 200 mc. This means that the voltage drop between terminals of such an instrument, an ammeter, is of the order of 300 to 350 volts with 5 amperes flowing. In addition to this disturbing condition, there are many stray and shunt capacitances through which such a voltage may force appreciable currents in the frequency range to 200 mc.

## THE CONVENTIONAL INSTRUMENT AT HIGHER FREQUENCIES

An analysis of a typical instrument of the conventional type shows that the actual high-frequency circuit between instrument terminals, neglecting resistance, approximates that shown in Fig. 4. This circuit consists essentially of four elements, namely:

1. The thermocouple unit, consisting of the heater wire $L_1$, compensating strips $L_3$ with their shunting capacitances $C_1$, and the thermocouple wires $L_2$.
2. The d-c instrument leads, represented by $L_4$, $L_5$, and $C_2$.
3. The d-c instrument, consisting of control springs $L_6$, moving coil $L_7$ with its shunt capacitance $C_3$, and the coil-to-magnet capacitance, $C_4$.
4. The inductance $L_8$ of the magnet, scale plate, and grounding strap, and their shunt capacitances to ground $C_6$.

There are in addition the various mutual inductances as shown.

The approximate nature of the circuit is apparent when it is noted that most of the parameters actually are distributed, rather than lumped. This fact, in addition to the complexity of the lumped parameter circuit and the difficulty of estimating or calculating accurately these parameters, led to the conclusion that a general qualitative approach with experimental verification on actual sample instruments would be preferable to a complete mathematical analysis of the approximate equivalent circuit.

Examination of Fig. 4, however, in conjunction with other known information, serves to point out the error-producing effects.

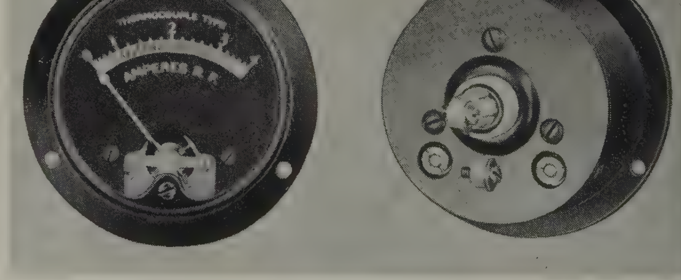

**Fig. 5. A low-impedance ammeter for use in the 0–200-mc range. The rear view on the right illustrates the concentric terminal arrangement**

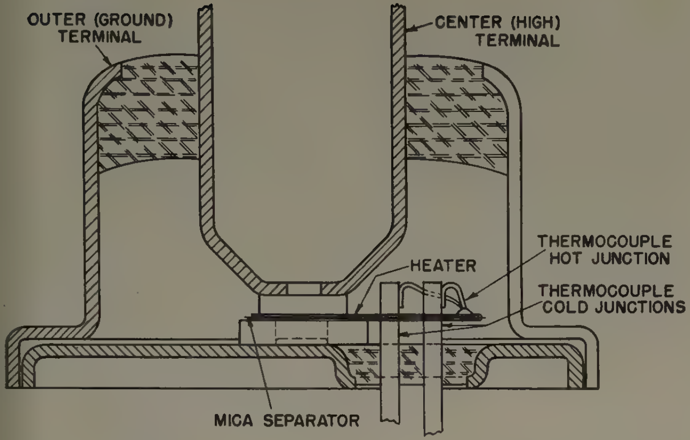


**Fig. 6. Cross-section view showing the construction of the low-impedance thermal converter**

In the first place, the shunt capacitances make possible the diversion of current from its intended path.

Secondly, it is evident that there is a major loop circuit starting at the thermocouple junction, proceeding through the compensating strips, the d-c instrument leads in parallel, via the moving coil to magnet capacitance, to the low terminal stud through the magnet and grounding strap, and back to the starting point through one-half of the heater wire. When it is considered that approximately half of the terminal-to-terminal voltage, which can be of the order of 100 volts or more, is included in this loop it is evident that heating of the thermocouple wires by the high-frequency current flowing in this circuit will be a considerable factor.

In addition, it is seen that there is the possibility of resonance in all of the many loops (including the major loop described) at various frequencies. Such resonances will produce localized heating effects having the sharply peaked characteristics associated with the resonance phenomena. There is also the possibility of induced circulating currents in the various loops produced by the linkage of high-frequency fields with these loops.

Since the thermocouple measures total heat, and does not distinguish its source, all of these heating effects cause errors in indication. The major sources of errors appearing in the thermocouple instrument at high frequencies therefore may be listed as follows:

1. Resistance rise due to skin effect.
2. Extraneous heating of the thermocouple wires due to high-frequency currents flowing in them.
3. Resonance effects in various of the loop circuits at various frequencies.

## AN INSTRUMENT FOR USE AT HIGHER FREQUENCIES

Consideration of these sources of error has led through various development stages to an experimental sample of a low-impedance thermocouple-type instrument in which such errors have been reduced greatly. This instrument, illustrated in Fig. 5, has a useful range of 0–200 mc, with minimum errors, and without troublesome resonance or impedance effects.

In this instrument a short concentric terminal arrangement replaces the usual side-by-side terminal studs which usually are separated by an inch or more. This configuration reduces the internal circuit length of the instrument, and assists in impedance reduction. It likewise serves to shield the d-c instrument parts from the high-frequency current field, and to prevent the series induction of high-frequency voltages in parts of the d-c instrument circuit. The outer terminal is grounded to the case, as are all other large metal masses in the instrument.

The heating element is made from a thin flat ribbon, rather than from the usual round wire, to reduce the skin-effect error as much as possible. For minimum skin effect the heater should be very thin; in fact, the thinner the better. Practically, however, it is necessary to compromise this with thermal requirements (which are dependent also on current ratings), so that it is not possible to eliminate entirely the effects of resistance change with frequency.

To lower the series impedance of the instrument further, the inductance of the heater is lowered by folding the flat-strip heater back on itself, forming a hairpin-like

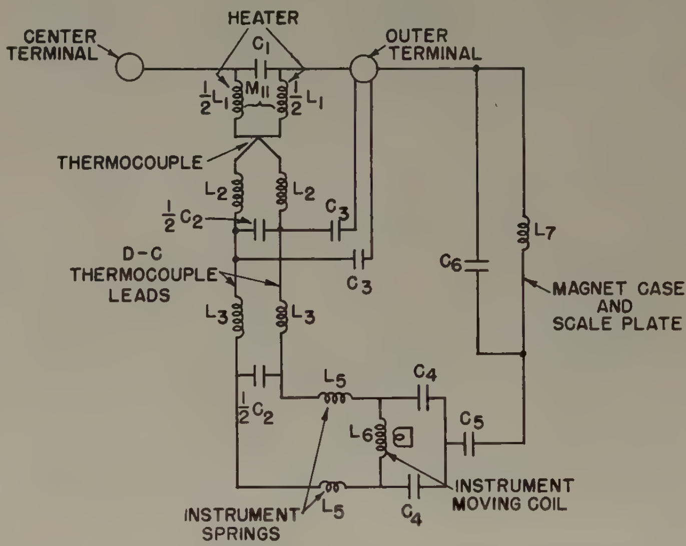


**Fig. 7. The internal circuit of the low-impedance thermocouple ammeter at high frequencies**

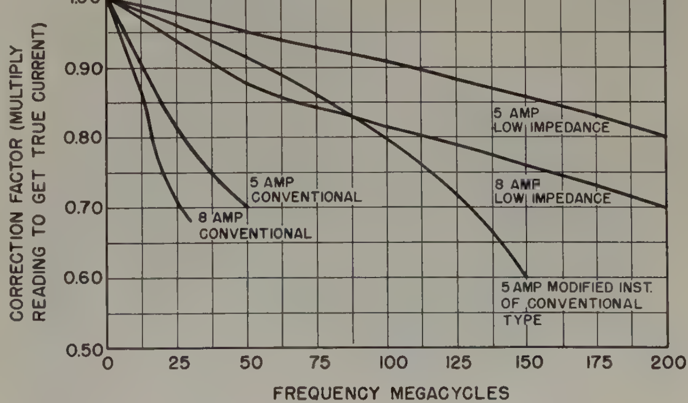


**Fig. 8. Correction-factor curves for the low-impedance thermocouple ammeters compared with those of conventional type**

structure whose two halves are separated and insulated by a thin sheet of mica. The path of high-frequency current is (see Fig. 6) in the center terminal, through the strip heater, and out the outer terminal.

The thermocouple junction itself is welded to the midpoint of the heater strip near the fold, and the cold junctions are welded to two small pins which are thermally intimate with, but electrically insulated from, the plate connecting the inner and outer terminals. This arrangement results in d-c thermocouple outputs equivalent in magnitude to those of the conventional arrangement.

To prevent any possible series induction in the d-c instrument loop circuit, the two leads from the thermocouple cold junctions to the instrument armature are twisted together along most of their length.

The details of the construction of this new thermal converter, which is of completely sealed construction, are shown in Fig. 6. (See also *U.S. Patent 2,199,247;* Rich, Meahl, and Michel.)

The approximate internal circuit of the low-impedance instrument is illustrated in Fig. 7. It is evident, from comparison with Fig. 4, that the major simplification is in the thermocouple converter itself, which is to be expected since the instrument mechanism and the leads to it do not allow any significant change. The main simplification is in the reduction of the number of loop circuits involving the heater and in the reduction of the shunt capacitances.

One of the most significant improvements in the instrument is the impedance reduction from terminal to terminal through the heater. The value of $L_1$ in Fig. 7 is approximately one-tenth that of $L_1$ in Fig. 4. This has the double effect of reducing the high-frequency voltage appearing across the heater part of the major loop previously discussed, and of raising the resonant frequency of this loop.

This design, therefore, reduces skin effect, reduces extraneous heating of the thermocouple wires by reducing the voltages (both induced and otherwise) tending to send high-frequency currents through them, and decreases resonance effects by eliminating some of the loop circuits and decreasing the inductance in others.

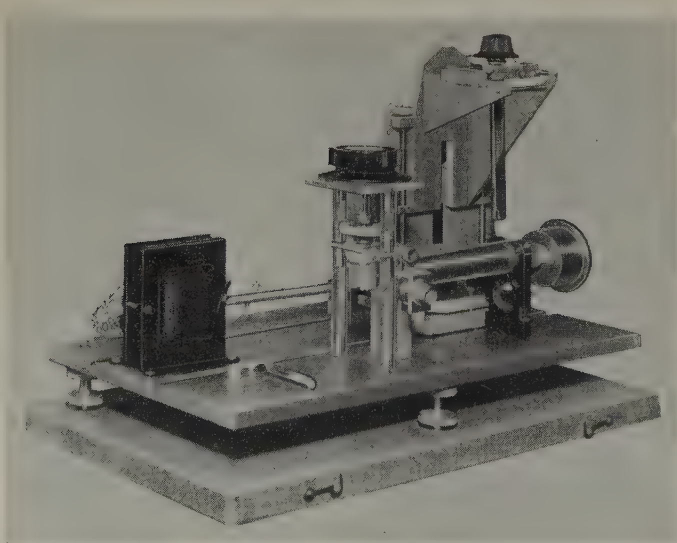

**Fig. 9. Electrodynamic high-frequency current standard**

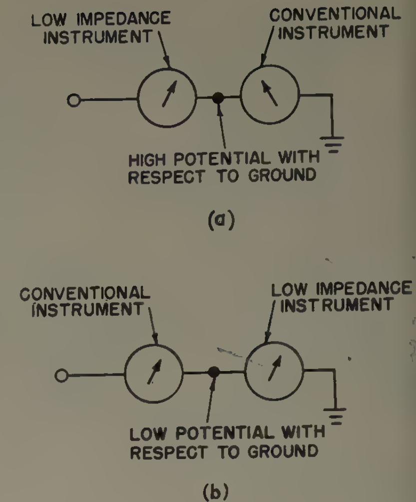


**Fig. 10. Circuit diagram showing the importance of low impedance in a thermocouple-type instrument and the significance of ammeter location in measuring circuits**

The actual effectiveness of this approach is demonstrated by the fact that instruments of this type are approximately one-tenth the impedance of the conventional type (the order of 6 ohms), that they are consistently inductive (approximately 0.005 microhenry) with no resonance points from 0 to 200 mc, and that their over-all errors, as indicated in Fig. 8, are lower than those of other thermocouple instruments. From Fig. 8, for example, it is seen that a low-impedance 8-ampere instrument has a correction factor of 0.88 at 50 mc, and 0.70 at 200 mc, while in a 5-ampere instrument the factors are 0.95 at 50 mc and 0.80 at 200 mc. The differences between the 5- and 8-ampere correction factors are due mainly to the necessity of using a thicker heater in the 8-ampere rating, thereby increasing skin-effect errors.

For comparison, Fig. 8 includes correction-factor curves on comparable instruments of conventional type, and of conventional type improved to lower skin-effect errors only. The correction factors on each instrument were obtained by comparing it with an electrodynamic high-frequency current standard, which is illustrated in Fig. 9 with an instrument under test. Considerable experimental work indicates that at frequencies of 50 mc and above, it is not possible to predict performance accurately from skin-effect and other calculations, the reasons for this having been pointed out previously in the discussion of the errors involved. In fact, instruments which are supposedly identical have been found to have considerably different errors. The theory of operation and establishment of the electrodynamic ammeter as a primary standard for high-frequency current measurement have been covered adequately elsewhere.[3-7]

A striking demonstration of the improvement realized in this low-impedance instrument is obtained by connecting it and an instrument of the high-impedance type in series and passing high-frequency currents through them. When connected as shown in Fig. 10*a*, with the low-impedance instrument at a higher potential, that instrument will read (with correction factor applied) considerably higher than the high-impedance ammeter. When the positions of the instruments are reversed, as in

Fig. 10*b*, and the proper correction factors applied to both instruments, their readings will be found to agree. The reason for the difference is the diversion of currents from high-potential parts of the circuit to ground, thus allowing current to flow through one instrument and not the other.

Such a demonstration as this also brings out another point: the current indicated by the low-impedance instrument is that current flowing into the center terminal, and not some other fictitious current indication produced by the variety of error-producing factors previously outlined.

## CONCLUSION

By the proper application of the principles outlined here in the design of a low-impedance thermocouple-type ammeter, it is possible to make accurate current measurements at frequencies from 0 to 200 mc with a minimum of disturbance of circuits, as well as to determine the relative magnitudes of currents. Since the variation of multiplying factors at different frequencies is minimized by these design principles, it has been proved possible to calibrate development sample instruments of low-impedance design so that they may be used accurately over a predetermined and extensive frequency range without correction.

Consideration of the theoretical aspects and the actual performance of the experimental sample indicate that the suggested low-impedance design would be limited to a maximum current of 8 amperes, and for measuring higher currents it is necessary to use high-frequency current transformers in conjunction with the instrument. This and other techniques involved in the application of instruments for current measurement at these frequencies represent an important subject in themselves, which cannot be covered in this article.

It is concluded, on the basis of the study described here, that the frequency range of the thermocouple-type ammeter can be extended substantially by adoption of suitable design principles.

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# A New Fully Supercharged Generator

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**This completely supercharged generator takes full advantage of increased gas pressures and has virtually no load limit because of temperatures. Although both simpler and more rugged than its partially supercharged predecessor, at the same time it permits the user to effect substantial savings in power plant space and costs.**

Several generators with supercharged rotors are in operation, the first having been installed $2^1/_2$ years ago.[1] At that time it was known and stated that supercharged internal conductor cooling also could be applied to the stator winding and stator core, as well as to the rotor. It is only by complete application to the entire machine that the full value of the method can be realized, and this article will describe such a machine.

The fully supercharged generator is a machine which offers distinct advantages to the user. These include advantages in:

| | |
|---|---|
| Weight | Differential expansion |
| Length | Conservation of critical materials |
| $H_2$ content | Cooler mounting (no flexible expansion joint needed) |
| $H_2$ consumption | Cooling water requirements |
| Light load efficiencies | Mechanical construction |
| Overload rating | Reactances |
| Cooling medium (helium is feasible) | Shipping clearances |

G. W. Staats and Bernard Koetting[2] have described features in addition to supercharging which were incorporated in the same machine. These additional features were to give a machine whose mechanical design took advantage of all the possibilities of supercharging and also

Full text of paper 54-48, "A New Fully Supercharged Generator," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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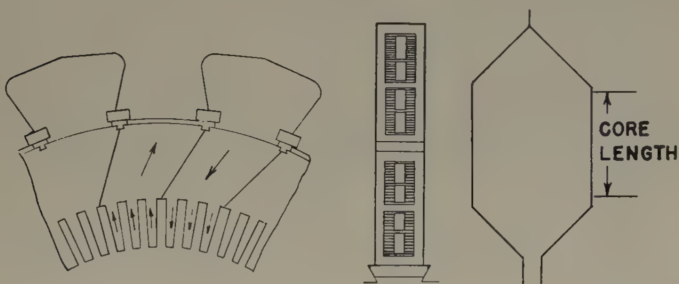
a machine which incorporated other new ideas not heretofore used.

## SUPERCHARGING

Supercharging is not merely the use of somewhat higher cooling velocities than normal. Since it involves a gas passage the full length of the rotor and stator coils and stator core, no load whatever can be carried with conventional gas pressures and cooling medium mass flows. It is not until enough mass flow of cooling gas is used so that no-load losses can be absorbed and still keep the temperature rise of the cooling gas below maximum permissible hot-spot temperature that even no-load operation is possible. From this point on, however, doubling the mass flow of the cooling gas substantially will double the amount of loss which can be absorbed for a given temperature rise. Thus, supercharged cooling involves a mass flow of gas which must be above a certain minimum value.

When the gas pressure in the housing is substantially atmospheric, then the cooling fans in the generator must produce many times the pressures heretofore used in non-supercharged cooling as can be seen from the 100-to-1 ratio of gas passage resistances indicated in Fig. 1 for full-length gas flow. If the gas pressure in the housing is raised to two or three atmospheres, then since the density of the gas is increased, the required cubic feet per minute of gas is decreased and fan pressures are reduced to a magnitude which can be obtained by means of special blowers.

The machine described has adequate cooling so that the limit in its ratings is not a thermal one but is determined by efficiency. In other words, its name-plate rating, was selected so that its efficiency would be as good as or slightly better than that of any normally designed machine now in production. Its light load efficiencies are improved because of the smaller proportion of fixed loss compared to those of conventionally cooled generators.




| | Normal Cooling | Supercharged Cooling | Ratio |
|---|---|---|---|
| Gas passage length | 2×slot depth | 2×core length | 10:1 |
| Gas passage area | 20%×core length×20%×gap periphery=4% of air gap area | 20%×slot width×80%×slot depth×number of slots=0.4% of air gap area | 1:10 |
| Hydraulic radius (=area/perimeter) | 30% of vent spacer height | 10% of slot width | 1:1 |

**Fig. 1. Typical comparison of cooling gas passages**

**Fig. 2. Scale models of conventional and fully supercharged 40-mw units**

## RATING

The machine which has been built has an AIEE–American Society of Mechanical Engineers standardized rating of 40,000 kw, except that the gas pressure required is 30 pounds per square inch gauge (psig) instead of $^1/_2$ psig. The large saving in power-plant space and costs resulting from the new cooling can be appreciated fully by reference to Fig. 2 showing the scale model of this unit compared with the conventionally cooled 40,000-kw machine.

The overload rating of the new machine in kilowatts will be limited by the turbine capacity. Its overload rating in kilovolt-amperes will be limited by how large an exciter is used but probably will be 60,000 to 70,000 kva at 45 to 60 pounds pressure.

## STATOR COIL COOLING

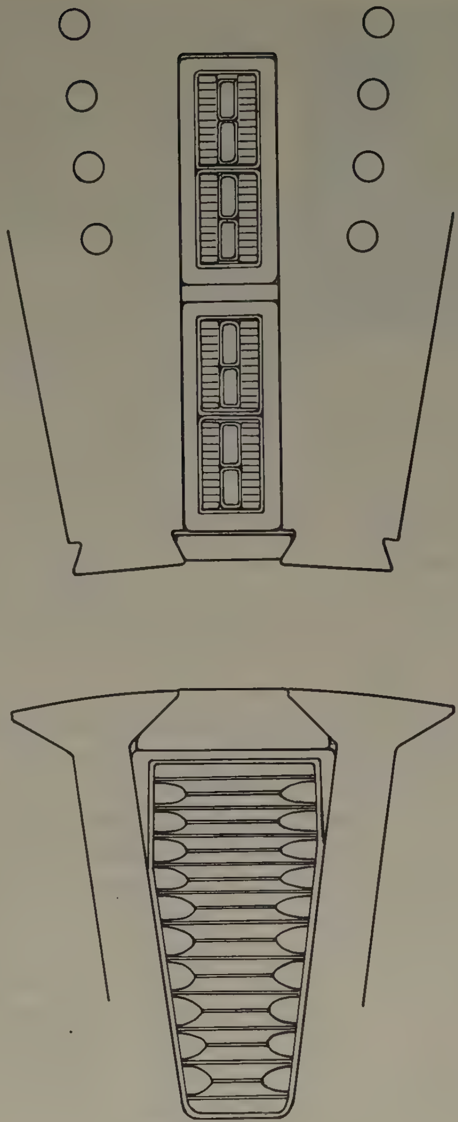
The stator coil cooling is by means of rectangular metallic tubes in the center of the coil as shown in Fig. 3. These tubes are each the depth of several strands and consequently should be made of high-resistance material such as monel metal or stainless steel in order to keep the eddy current losses low. They also have as thin a wall as possible mechanically and this further reduces the eddy current loss in the tube.

Cooling by means of hollow stator strands was considered and is possible with high gas pressure or with liquid, but is not as good as the scheme used because it requires deeper strands and, consequently, results in greater strand eddy current loss. This conclusion is the reverse of that reached on the rotor, where only direct current is involved and deep conductors may be employed permitting ducts in the rotor copper as shown in Fig. 3.

Contact between the stator strands and the tube wall was studied and a construction using silicone rubber adopted in order to give the lowest possible thermal drop. Test data with this construction are shown in Fig. 4. The drop from the strand to the metal of the tube, and likewise the drop from the metal tube surface to the gas, are seen to be of minor importance. The major factor determining coil temperature is the rise of gas temperature as the gas passes through the full length of the stator coil.

One factor which has been made use of in the design of

this machine is the vent duct space which ordinarily occupies about 20 per cent of the stator core. With the stator core cooling described in the following there are no radial stator vents in the machine and the stator iron is stacked solidly from one end of the core to the other. The 25 per cent extra stator area which thus becomes available for magnetic flux cannot be utilized fully for flux-carrying purposes because of limitations in the rotor magnetic circuit. Therefore, this extra area is largely available for use in making the stator slots wider. If all of the space gained by omitting stator vents were used for this purpose the stator copper could be made almost twice its normal width. This extra stator space alone more than makes up for the space occupied by the ventilating tubes in the stator coil. Extra width of stator slots ordinarily is avoided in normal design because it produces extra rotor surface stray loss; but with complete supercharging, the air gap length increases to such an extent that it more than offsets the extra slot width.



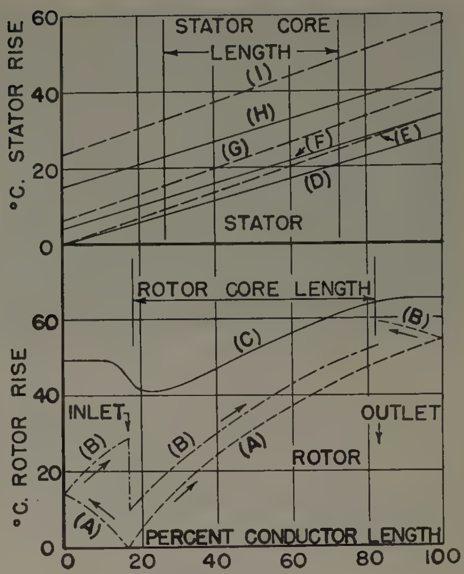



**Fig. 3 (left). Cross section of stator and rotor slots. Fig. 4 (above). Temperature distribution along length of stator and rotor conductors: A—Gas rise on one side of conductor; B—Gas rise on other side of conductor; C—Rotor copper rise; D—Stator gas rise at 30 psig, full load; E—Stator gas rise at 45 psig, $1^1/_4$ load; F—Stator duct rise at 30 psig, full load; G—Stator duct rise at 45 psig, $1^1/_4$ load; H—Stator copper rise at 30 psig, full load; I—Stator copper rise at 45 psig, $1^1/_4$ load**

## STATOR CORE COOLING

The stator core is cooled by small holes in the stator laminations which stack up to give lengthwise gas passages through the stator core, see Fig. 5. The size of these holes is co-ordinated with the size of the stator-coil cooling ducts so that full use is made of the available gas pressure and so that adequate area is available for contact with each lamination. This actually works out to give core gas passages about equal in number and size to the stator-coil cooling tubes since the stator-coil copper loss and the stator core loss are approximately equal. The use of high gas-scrubbing velocities and contact with every lamination will give a high uniformity of cooling and will avoid the high thermal resistance encountered when heat is conducted perpendicular to the stator laminations.

## ROTOR COIL COOLING

The rotor coil cooling on this machine also uses end-to-end gas flow so that it matches the stator core and stator coil cooling. This is a considerable improvement mechanically from previous supercharged rotors as it eliminates the need for gas discharge ducts in the center of the rotor. However, even though it is much better mechanically, it is interesting to note that doubling the gas passage length increases the fan pressure requirements by eight to one. First, twice as much heat must be picked up by the gas that enters the duct since it continues twice as far and can rise only to the same safe temperature limit so that twice as much gas is required. Second, the duct is twice as long. Thus, the fan pressure required must be multiplied by two because the duct is twice as long and by four because the gas velocity must be doubled, or by a total multiplier of eight. The fan volume requirement does not need to be increased as the same total heat loss is absorbed by the gas. In a machine with conventional cooling, doubling the machine length ordinarily only doubles the cubic-feet-per-minute requirements of the fan and does not increase the pressure requirements as parallel paths can be used.

As shown in Fig. 6, the gas for the rotor ducts is taken directly from the pressure chamber at the turbine end of the machine through openings below the end disk and then into the rotor coil ends. The gas enters the rotor coils at alternate diagonal corners and, as in previous designs, as much gas as possible is by-passed around the coil end and admitted to the coil at the end of the core. While this pro-

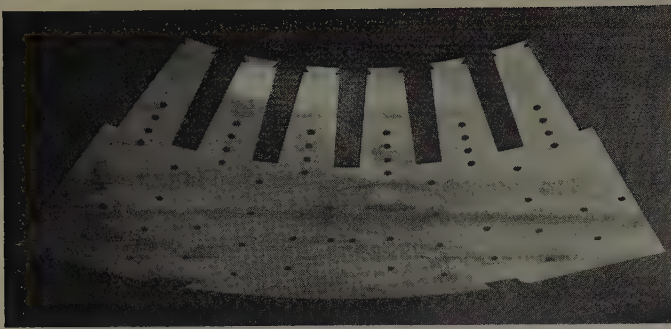


Fig. 5. Stator core lamination

cedure makes the coil ends at the entering gas end slightly warmer it improves the cooling at the outlet end of the machine because it gives a 5 to 10 per cent greater flow of gas. Fig. 4 shows the temperature distribution along the length of the rotor coil. The ducts through which the rotor gas flows are similar to those which have been described before and are as shown in Fig. 3.

It will be noted from this figure that the rotor slot is tapered and the rotor tooth has parallel sides. This is a somewhat different design than normal and was made possible by the fact that since the rotor copper was made lighter by the amount of copper machined away for the cooling ducts, the slot could be made wider without unduly increasing the slot wedge stress or depth. Actually, the gain due to tapering the rotor slot could have been achieved in part independently of supercharging. The study on magnetic saturation described[2] was also a factor in this design using parallel-sided rotor teeth.

## AIR GAP COOLING

The rotor stray losses, the rotor windage loss, and part of the stator tooth loss are taken care of by gas in the air gap. This gas is controlled as has been done before by a restricted clearance at the end of the air gap. However, in this case, the restriction is more drastic because of the smaller fraction of losses which are taken to the gas in the air gap and because of the larger air gap. This small gas flow through a large air gap and consequent low axial gas velocity does not handicap cooling because scrubbing velocity on the stator and rotor surfaces is obtained as a result of the high peripheral speed and is not dependent on high axial velocity of the gas.

## COOLERS

When coolers for a supercharged machine are considered, the first preference is for a cooler extending from one end of the machine to the other and having lengthwise gas flow. This so co-ordinates the cooler with the axial gas flow through the generator that in passing through the cooler the air is returned from one end of the machine to the other and almost no ducts are required. The second factor in cooler design is to have a cooler which makes use of the extra pressure drop available. In an ordinary design the coolers may use 20 per cent of the pressure produced by the cooling fan. In a supercharged machine they may use only 10 per cent of the total fan pressure, but this 10 per cent is a much greater actual pressure drop than 20 per cent of normal fan pressure.

The coolers actually used incorporate both of these desirable properties, i.e., they have axial gas flow and a moderate pressure drop. Although seldom used heretofore in rotating machines, they are a standard cooler on which much experience was available in other services. They have cooling fins which are parallel to the tubes, and they have bayonet-type concentric tubes so that both water heads are on the outboard end of the machine. Special provision for expansion and contraction is not needed with this construction, and cleaning can be done without removing hydrogen from the generator. Since the kilowatt loss of the machine is the same as that for a standard machine it has not been possible to reduce the over-all size of the coolers

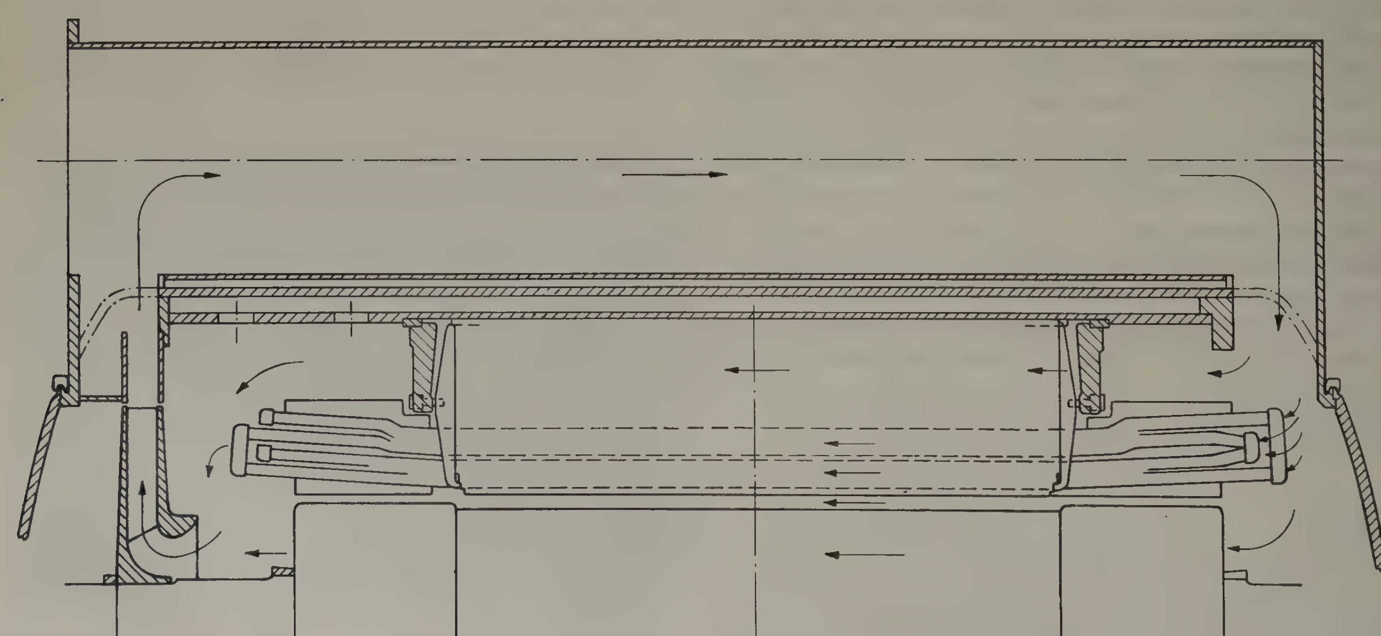
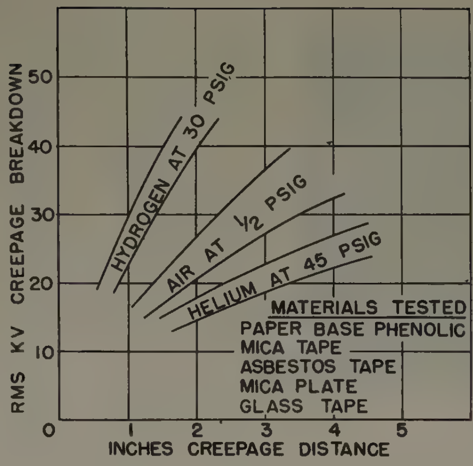


Fig. 6. Generator gas flow

in proportion to the over-all size of the generator frame. However, an appreciable gain was accomplished by using higher velocities and gas pressure drops in the cooler. A very considerable reduction also was made in cooling water requirement for the coolers because the higher outlet temperature and the higher gas velocities permitted the cooling water to pick up about twice as many kilowatts per gallon per minute as is done normally. The cooling water requirements are thus but half those of a normal machine. The heat transfer rate from gas to liquid is improved somewhat because the flow is direct counterflow instead of a combination of cross flow and counter flow used in normal machines.



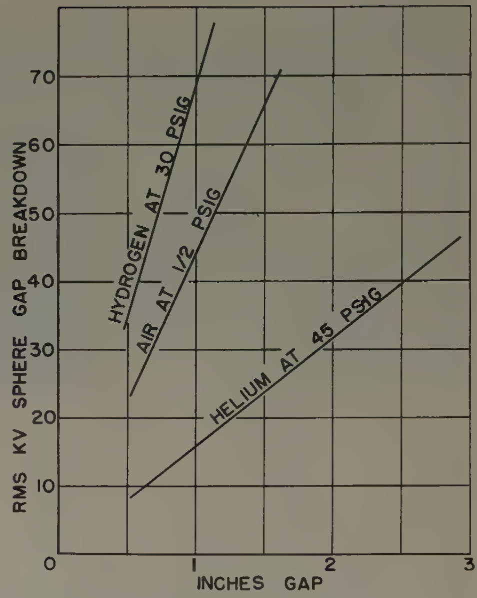




**Fig. 7 (left). Creepage curves for various typical insulating materials. Fig. 8 (right). Spark-over curves**

While 40 C is the normal cooler outlet gas temperature at rated load, it is not considered a part of the rating and is not held under other conditions. The machine design is based on 90 F inlet water conditions and on established AIEE temperatures.

## CREEPAGE STRENGTH OF STATOR COIL ENDS

A SUPERCHARGED stator coil has cooling gas entering the coil at the U-bend on one end of the generator and discharging at the U-bend on the other end. The points of gas entrance and exit necessarily must be points where the interior of the cooling ducts or tubes in the stator coils is exposed to the cooling gas. Thus, there is substantially bare conductor metal at each U-bend, and adequate provision must be made in the design for creepage and flashover strength between turns, between adjacent coil U-bends, between phase belts, and from U-bend to ground. This is not difficult to do, but an experimental study was made in both hydrogen and helium atmospheres because of the possibility of using helium as a cooling medium instead of hydrogen either for emergency operation or continuously as long as temperature rise is no limitation.

Tests on creepage strength in hydrogen and helium are shown in Fig. 7 where they are compared with those in air under similar conditions. These tests indicate two things. First, that hydrogen and helium have lower breakdown creepage strength than air and, second, that above 18 psig the creepage breakdown in hydrogen is better than in air at atmospheric pressure. Creepage strength at 45 psig in helium is less than in air at atmospheric pressure but the machine has been designed to allow for this, and permit safe operation in helium at this pressure. Similar data on spark gap breakdown tests in the different gases are shown in Fig. 8, and show that this type of breakdown behaves similarly to creepage, hydrogen being slightly more favorable and helium somewhat less. By utilizing these data in the design and making model coils for tests it is known that with the design and hydrogen pressure being used, the generator insulation strength to ground and between coils and between phases is equal to, or greater than, that in a normal machine.

One of the things which has been done to achieve this dielectric strength has been to design stator coil ends so that the separation between the adjacent phase belts is very considerably greater than the separation between the adjacent coils in one phase belt.

## BLOWERS

THE BLOWER used, see Fig. 9, resembles a conventional compressor wheel and is mounted on the outboard end of the shaft so that it does not interfere with rotor removal. The entrance and exit conditions of the blower are, however, not quite the same as on a conventional blower. The entrance gas has some prerotation because part of it is coming directly from the air gap of the machine and part from the rotating end disk of the rotor. Furthermore, the rotor end, shaft, and blower coverplate tend to rotate the remaining air by surface friction effects. To minimize these effects a stationary shroud in front of the blower wheel is used. The wheel discharge conditions

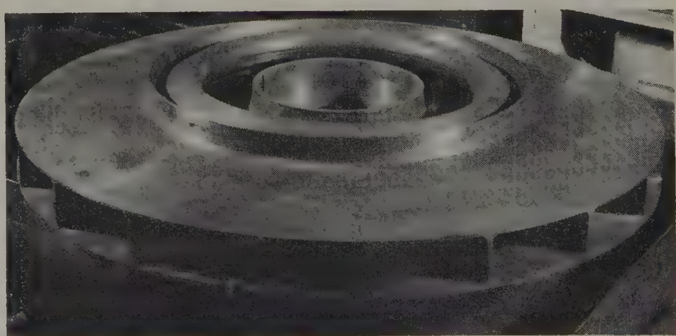


**Fig. 9. The single-stage blower**

**Fig. 10. Scale model blower test setup**

are substantially normal except that the diffuser outer diameter is limited by the generator housing diameter and the volute (which is double because there are two coolers) is by the side of the diffuser instead of being around its outer periphery.

These somewhat special inlet and outlet conditions, together with the relative high-pressure requirements and low-volume requirements, made it desirable to test the scale model which is shown in Fig. 10. This model is complete with cooler housings and dummy rotor and stator ends (not shown) and gave very reliable over-all test data. Among the many interesting test results obtained from these studies are a series of static pressure readings at various positions in the rotating impeller, tested while running by means of metal tubes visible in Fig. 10 within the hub circle.

As a result of these tests and partly by the use of 30-psig cooling gas, it was possible to have a single-stage blower instead of the double-stage blower used on the machine now in service with rotor supercharging only.

## POWER PLANT SAVINGS

THE short rotor removal distance of this 40-megawatt (mw) machine will save 10 feet of power plant width, with corresponding reduction in crane span and lifting capacity where the stator is the heaviest piece to be handled. The stator weight for this new design is only a fraction of that for conventional cooling. The corresponding reduction in plant width for a 150-mw standardized unit would be 22 feet, and at least 11 feet of foundation length can be saved also.

The reduction in first cost of a power plant resulting from the shorter, lighter, supercharged 150-mw unit will vary in various localities and with different unit arrangements and plant designs. Typical cost estimates for steam power plant buildings range from 75¢ to $1.05 per cubic foot depending on many factors. A conservative estimate on an incremental basis might be taken as 50¢ per cubic foot. The shorter design would save about 54,000 cubic feet of space (equivalent to $27,000) for a standard 150-mw unit. When generators are arranged side by side, the crane span as well as its lifting capacity can be decreased. The resultant reduction in initial cost approaching $200,000, although ultimately to be distributed among two to five units in a typical plant, still would be an appreciable saving per unit.

The 2-pole fully supercharged machine has reactances almost identical to those of a large 4-pole generator. When full advantage of the higher subtransient reactance can be realized in switchgear selection further savings of from $5,000 to $20,000 may be possible depending upon bus arrangement. These considerations are equivalent to a substantial reduction in the installed first cost of the fully supercharged generator.

## CONCLUSIONS

THE PRESENT completely supercharged generator is in many ways simpler and more rugged than the partially supercharged generator described 2 years ago. It takes full advantage of increased gas pressures, and virtually has no load limit because of temperatures. Its axial core length is less than half that of the equivalent conventionally cooled machine and its average and differential temperatures are lower, greatly reducing the seriousness of differential expansion.

By utilizing the internal space more effectively, the quantity of gas in the fully supercharged generator has been cut in the ratio of 5 to 1 from the volume of its conventional predecessor. Its small bearings and seals minimize lubrication requirements, hydrogen consumption, and mechanical maintenance. The weight and size reduction permits complete factory assembly of the largest machines and shipment without dismantling. It also affords the user substantial economies in power plant space and costs.

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# Ultrasonic Sandpaper Making

Ultrasonics and electronics have been used to improve manufacturing of sandpaper. According to a report from the Carborundum Company, ultrasonic waves, introduced into the adhesive mix, measure the sound-wave energy required to cause the layers of adhesive to slosh back and forth over one another. This energy is proportional to the viscosity of the mix. This is calculated by an electronic computer which feeds the data to a special electronic recording-controlling instrument, designed by Minneapolis-Honeywell, which automatically maintains the viscosity of the fluid at the proper level.

# Analyzer Interconnections for Power Swing Curves

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THE CALCULATION of power-system swing curves generally is performed by using one of several point-by-point techniques in conjunction with an a-c network analyzer. The technique is well known and while greatly simplified by use of the network analyzer is still laborious and time-consuming. At least one analogue for the automatic and continuous determination of swing curves has been devised and several have been proposed. This digest illustrates a method for direct determination of swing curves by interconnection of a network analyzer with a differential analyzer.[1]

The oscillation of a generator rotor in transient stability studies is ordinarily given by

$$\delta(t)=\frac{180f}{H}\int_0^t\int_0^t (T_m-T_e)dtdt \qquad (1)$$

In practice this integral usually is approximated by a sum of finite differences, using the network analyzer to provide the successive values of $T_e$. At the end of every step each rotor angle $\delta$ is adjusted by the calculated increment.

Fig. 1 illustrates in block diagram form the essential features of the two analyzers and their interconnection. The electric power supplied to the network is metered at the generator wattmeter and converted by an operator to shaft rotation. Synchros are used to transmit this rotation to the differential analyzer, which solves equation 2 with two integrator units and appropriate gear trains. The power angle obtained from the computation then is fed back continuously to the generator rotor of the network analyzer. Plots of actual swing curves (angle-time curves) are obtained on differential analyzer output tables.

The system of Fig. 1 was tested by comparison with known solutions. Fig. 2 shows the effect of interval size in the point-by-point method of solution in a simple 1-generator problem. As would be expected the cumulative errors of the stepwise techniques have been minimized in the computer solution. The three curves illustrated compare the continuous solution to that obtained step wise using intervals of 0.05 and 0.01 second. Agreement of successive continuous solutions was within 2 per cent. Comparison with other analytical data shows over-all accuracy also to be within 2 per cent. The method described is inherently limited to network analyzers with low-regulation generators.

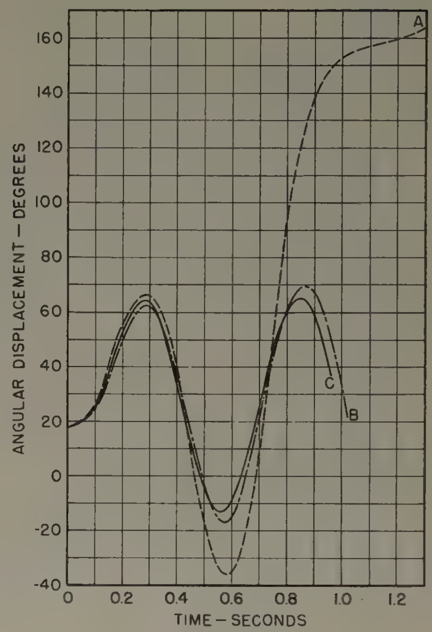


**Fig. 2. Generator swing curves**

*A—Point-by-point solution using interval of 0.05 second; B—Point-by-point solution using interval of 0.01 second; C—Computer solution*

While a human operator was used as a power-to-shaft motion transducer in the diagram of Fig. 1, it is possible to use automatic methods if economically justified.

It should be noted that while a mechanical differential analyzer was used in the present setup, electronic integrators might be equally suitable. The interconnection of the network analyzer with a general-purpose computer offers possibilities of studying nonlinearities connected with excitation systems, governor characteristics, or damping torques. The steady-state behavior of the power system can be studied independently on the a-c board and the system as set up can be interconnected with a computer to handle problems of transient stability.

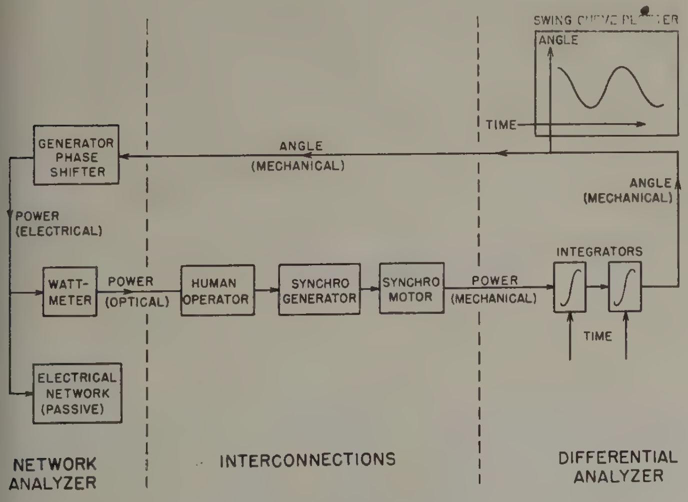


**Fig. 1. Block diagram of analyzer interconnections**

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# A Tungsten Resistance Thermometer

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THE USE OF tungsten wire for the sensing element of a resistance thermometer is not new to the art. However, to the best knowledge of the authors, this thermometer, Fig. 1, is the first successful one with stabilities as good as, or better than, platinum.

Tungsten offers many advantages as the sensing element of a resistance thermometer. Among these are its high melting point (3,380 C) and large change in resistance with temperature. It is also readily available from the manufacturers of electric light bulbs, in the form of high-purity ductile wire.

Fig. 1 illustrates the mechanical construction of the thermometer.

In the manufacture of a resistance thermometer three qualities of the resistance element must be established. These are the resistance-temperature coefficient, the resistance at some reference temperature, and the stability.

The first adjustment to the bulb is made by placing the assembly in an annealing furnace to set the temperature coefficient. Smithells[1] has shown that the temperature coefficient of resistivity of tungsten after cold work increases with the annealing temperature from about 0.36 up to 0.49 per cent per degree C at 2,500 C. It has proved to be practical to anneal to a predetermined temperature and thus adjust the temperature coefficient to the required accuracy.

The resistance adjustment of resistance thermometers usually is performed mechanically. The wire is cut to give the proper value or has its cross section reduced by filing after the anneal. This adjustment process results in further strain, which must be removed by additional anneal before stability is assured. This can be a long and difficult process when high precision is desired. It has been found

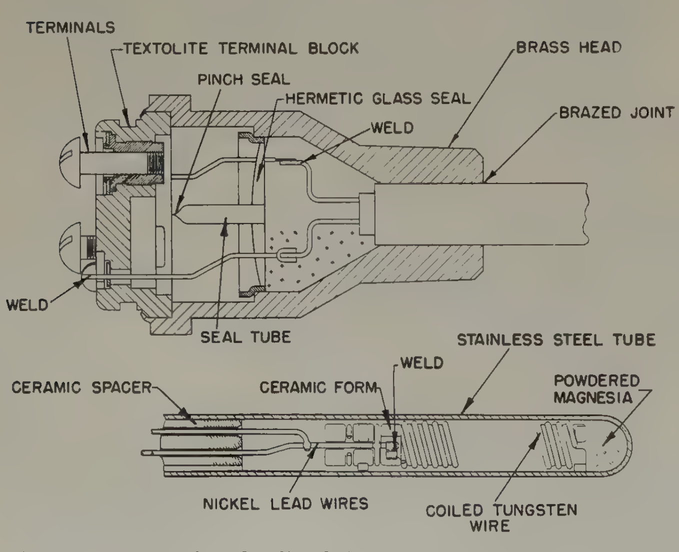


**Fig. 1. Construction details of the tungsten resistance thermometer**

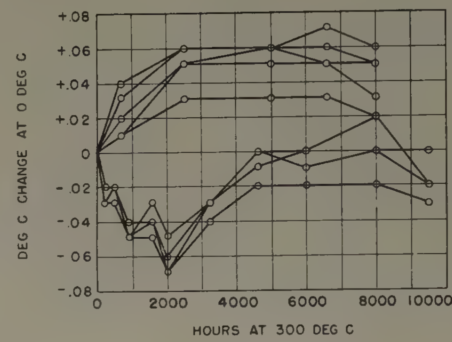


**Fig. 2. Stability tests showing variation of resistance at 0 C after exposure to 300 C**

possible to adjust the tungsten bulb by a chemical process which can be carried out almost automatically. This adjustment follows the anneal previously described and is done on the complete assembly with the tungsten sensing element inside the stainless steel tube. Extremely high adjustment accuracy is possible.

At the completion of the coefficient and resistance adjustment the bulbs are filled with a fine ceramic powder which is poured in through the seal tube. This powder is packed as tightly as possible by vibrating the tube during filling. The air remaining in the voids of the filling then is pumped out and replaced with pure helium gas, the bulb is sealed, and the thermometer is ready for use.

In addition to accurate initial readings, the bulbs must maintain accuracies for long periods of time. Fig. 2 shows the change in calibration at the 0 C point after exposure to 300 C for the hours indicated.

During the stability tests shown in Fig. 2, a standardized platinum bulb was used as a reference to check the test equipment and the 0 C reference temperature. It was interesting to observe that the best of the tungsten thermometers often showed greater stability between tests than the platinum standard.

The inherent temperature limitations of the commonly used metals such as copper, platinum, nickel, etc., are well known. The best of these materials, platinum, has an upper range of approximately 600 C. However, experiments conducted with tungsten show excellent stability at temperatures up to 1,000 C. Since the range is no longer limited by the inherent properties of the sensing element material, it can be expected that the upper temperature limit of resistance thermometers will be increased during the next few years.

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# Automatic Flight Control System Using Rate Gyros for Unlimited Maneuvering

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**Feedback control techniques have been applied to automatic flight control problems to produce a new type of automatic pilot. It provides unlimited maneuverability by using three simple nontumbling rate-type gyroscopes to regulate the angular velocity of the aircraft about its principal axes. The three basic control loops, without use of vacuum tubes, combine electric and hydraulic power boost means in proportional-type servomechanisms which actuate the aircraft's control surfaces.**

EXPERIENCE gained during the war using restrained gyros[1–3] for zero angular rate stabilization of guns led to a program of adapting these simple devices for aircraft stabilization. The use of such gyros to regulate fixed angular rates as in curved flight or in rolling or looping appeared to be a natural application. Also, their nontumbling character and their freedom from response to acceleration were very desirable.

To this simple basic system suitable reference signals were added for straight-line flight and for co-ordination in turns. The objective of simplicity as well as the retention of the desirable features of the simple rate system have been uppermost in the choice of such positional references.

In the past, conventional automatic pilots have used a gyro-vertical to measure the angular deviations about the roll and pitch axes and thereby regulate the attitude of the aircraft in space. These systems are not suitable for highly maneuverable aircraft because of the inherent limitations in angular deflection of a free gyro and the acceleration errors in the pendulous erection devices used in gyro-verticals.

No gyro-vertical is employed in the new autopilot system. A novel altitude-rate control which supplies signals proportional to the pressure altitude and the rate-of-change of pressure altitude is used to bias the pitch-rate gyro for maintaining level flight or any desired rate of climb or dive. This device is not influenced by accelerations of the aircraft. In place of the conventional bank angle reference a pendulous bank co-ordinator applies a mechanical force to the roll-rate gyro to level the wings for fixed heading and to maintain accurate bank co-ordination during turns regardless of air speed.

New methods for co-ordination when entering and leaving a turn have been developed. For example, when entering a turn a transient co-ordinator immediately applies a roll-rate signal to the aileron system causing the airplane to start banking. Delayed rudder and up-elevator deflections appear as the airplane develops its bank angle, and the roll-rate signal is removed gradually as the bank angle is acquired.

In straight flight a compass signal may be employed to monitor the yaw system. The absence of a gyro-vertical under these conditions can give rise to a lateral oscillation similar to "Dutch roll" unless proper steps are taken. This is more pronounced because of the added co-ordination control of the bank pendulum. The solution was found to be a cross-feed of yaw rate into the bank axis in a direction to hold the wings level, i.e., to prevent co-ordination if an unwanted yaw disturbance occurs.

## GENERAL DESCRIPTION OF AUTOPILOT SYSTEM

TWO distinct modes of flight control are possible with the autopilot system to be described. These are shown schematically in Fig. 1 and identified by the position of a selector switch on the flight controller. The "On" position provides for co-ordinated flight and a "Boost" position permits unlimited maneuvering. The flight controller has a single control knob with three degrees of angular freedom about axes which are parallel to the three principal axes of the aircraft.

In the "On" position rotation of the control knob in azimuth results in co-ordinated turns which persist as long as the knob is off center. When the knob is centered in azimuth, a compass signal is applied to the turn-rate gyro to maintain a fixed course. When the knob is centered in the pitch direction, the altitude-rate control supplies signals to the pitch-rate gyro which are proportional to the pressure-altitude and to the rate-of-change of pressure altitude. The pressure signal maintains the airplane at a fixed altitude and the pressure rate-of-change signal supplies damping about the pitch axis of the aircraft. Rotation of the control knob from its center position in the pitch direction removes the altitude slaving signal and provides regulated rates of climb or dive. A side slip may be introduced during co-ordinated flight by deflecting the knob about its roll axis.

With the selector switch in "Boost," all positional influences are removed and unlimited maneuvering of the aircraft can occur. The autopilot now consists of three independent rate systems coupled aerodynamically through

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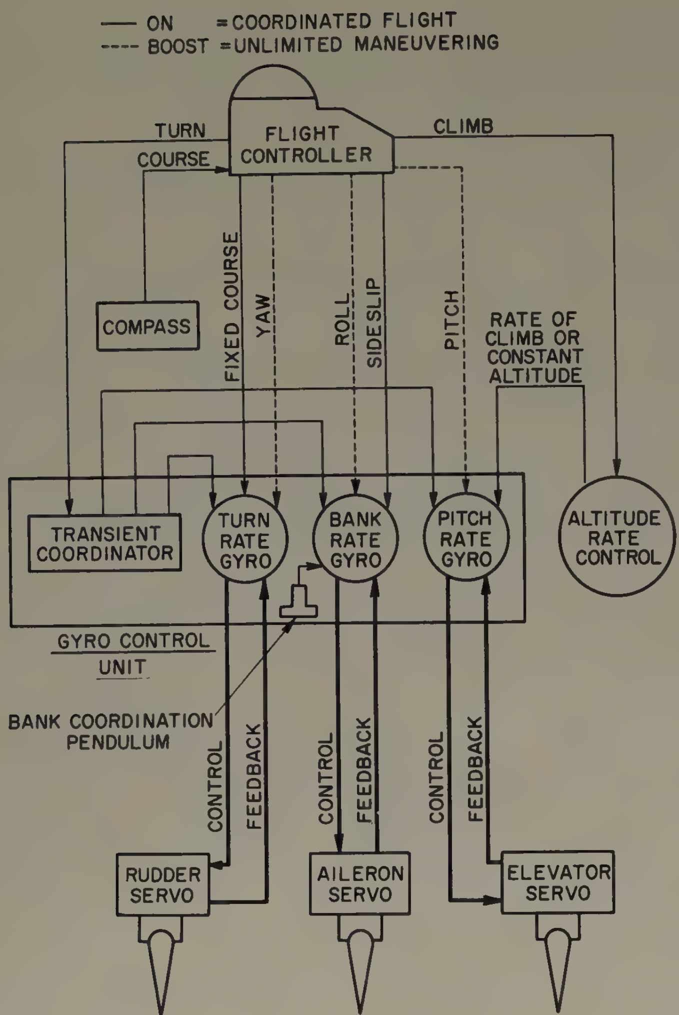


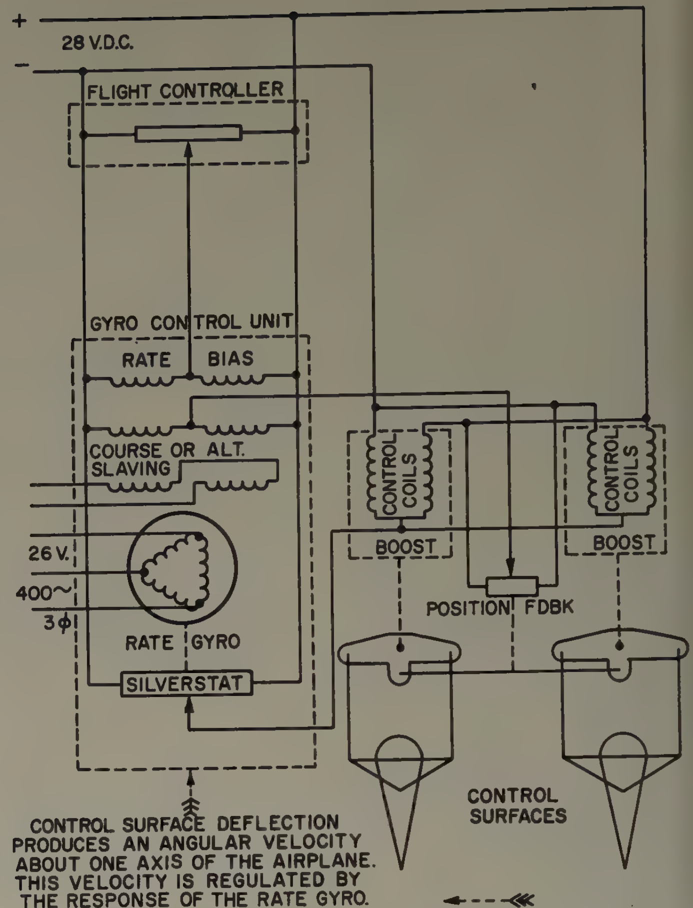




**Fig. 1 (left). Flight control modes. Fig. 2 (above). Basic single-axis control system**

the air frame. Rotation of the controller knob about any of its axes results in an angular rate about the corresponding axis of the aircraft. Any flight co-ordination now must come from the human pilot and the control is similar to that of a power boost system except that the rate gyros always are acting to supply the damping required for flight stabilization.

One of the basic single-axis control loops, consisting of a rate gyro and a hydraulic boost servo which positions the control surfaces of the aircraft, is shown in Fig. 2. The gyro control unit has a Silverstat transducer which is deflected mechanically by either gyroscopic forces or forces introduced by the unbalancing of several pairs of biasing coils arranged in bridge circuits.

A deflection of the flight controller unbalances the rate bias coils resulting in unbalanced torques which deflect the transducer. The transducer output controls the coils of a hydraulic multiplier valve which in turn positions a boost cylinder and the control surfaces. A potentiometer, driven by the control surfaces, unbalances another pair of biasing coils in the gyro control unit to give a negative feedback torque and make the control surface deflection proportional to the input bias torque. If the angular velocity of the airplane differs from that called for by the net biasing torques, the rate gyro will add a precession torque to the transducer in a direction to produce the called for velocity.

The frequency response and phase shift of the inner loop hydraulic boost system is shown in Fig. 3. In the stability calculations which follow, this part of the system is represented by the transfer function $Y_1(p) = \dfrac{1}{0.0025p^2+0.06p+1}$.

## GENERAL DESCRIPTION OF AUTOPILOT-AIRCRAFT COMBINATION

The manual control of an aircraft in space is not a simple problem. Therefore, when an autopilot as described is added to obtain automatic flight control, the result is a rather complicated feedback system. However, the vertical plane of symmetry found in all airplanes simplifies the equations of motion so that it is necessary to consider only the longitudinal and lateral motions of the airplane. The general equations for both longitudinal and lateral motions of the airplane are well known and can be simplified by certain assumptions which do not affect materially the over-all system performance of the combined autopilot and airplane.

A block diagram of the closed-loop longitudinal control system is shown in Fig. 4. The longitudinal motion of the aircraft simplified by assuming constant air speed and level flight can be represented by the following equations:*

$$Z_\alpha\alpha+Z_q p\theta+Z_{\delta_e}\delta_e+mVp\gamma=0 \qquad (1)$$

$$I_y p^2\theta=[M_{\dot{\alpha}}p+M_\alpha]\alpha+M_q p\theta+M_{\delta_e}\delta_e \qquad (2)$$

For equilibrium in lift, equation 1 shows that the sum of the forces along the $Z$ axis which is proportional respectively to the angle of attack $\alpha$, the pitch velocity $p\theta$, the elevator displacement $\alpha_e$, and the centrifugal acceleration $Vp\gamma$, normal to the flight path, is equal to zero. For equilibrium in pitch, equation 2 shows the moment resulting from the inertia and angular acceleration of the airplane equal to the sum of the moments coming from the rate-of-change of angle of attack $p\alpha$, the angle of attack $\alpha$, the rate-of-change of pitch angle $p\theta$, and the elevator deflection.

The autopilot can be presented by the following differential equation which equates the hinge moments of the autopilot to the aerodynamic hinge moments of the elevator

$$\left[\frac{E_hV\gamma}{p}+E_{\dot{h}}V\gamma+E_qp\theta\right]Y_1(p)=H_e\delta_e \tag{3}$$

In this equation $Y_1(p)$ is the transfer function of the inner loop of the automatic pilot, and $E_h$, $E_{\dot{h}}$, $E_q$ are coefficients determined by design constants of the altimeter, vertical-rate control, and pitch-rate gyro respectively ($\gamma$=angle of flight path to horizontal $=\theta-\alpha$).

Fig. 6 is a block diagram of the closed-loop lateral control system where the airplane's motion is characterized by the following three equations:

$$mVp(\psi+\beta)=Y_\beta\beta+Y_rp\psi+mg\phi \tag{4}$$

$$I_xp^2\phi=L_pp\phi+L_\beta\beta+L_rp\psi+L_{\delta a}\delta_a \tag{5}$$

$$I_zp^2\psi=N_rp\psi+N_\beta\beta+N_pp\phi+N_{\delta r}\delta_r \tag{6}$$

The lateral forces in side slip are given by equation 4 which shows the centrifugal acceleration forces resulting from yawing and side-slipping equal to the sum of the lateral forces proportional to the side-slip angle $\beta$, the yaw velocity $p\psi$, and the bank angle $\phi$ respectively.

* Conventional National Advisory Committee for Aeronautics symbols are used where practical. Fig. 5 illustrates the principal axes and symbols.

In equation 5 the roll torque $I_xp^2\phi$ resulting from the inertia and angular acceleration of the airplane is equal to the sum of roll torques proportional to the roll velocity $p\phi$, the side-slip angle $\beta$, the yaw velocity $p\psi$, and the aileron deflection $\delta_a$.

Equation 6 shows the yaw acceleration torque $I_zp^2\psi$ equal to the sum of yaw torques proportional to the yaw velocity $p\psi$, the side-slip angle $\beta$, the roll velocity $p\phi$, and the rudder deflection $\delta_r$.

The dynamic response of the automatic pilot for lateral control is represented by the following hinge moment equations for the rudder and aileron:

$$[R_rp\psi+R_\psi\psi]Y_1(p)=H_r\delta_r \tag{7}$$

$$[A_pp\phi+A_rp\psi+A_\beta\beta]Y_2(p)=H_a\delta_a \tag{8}$$

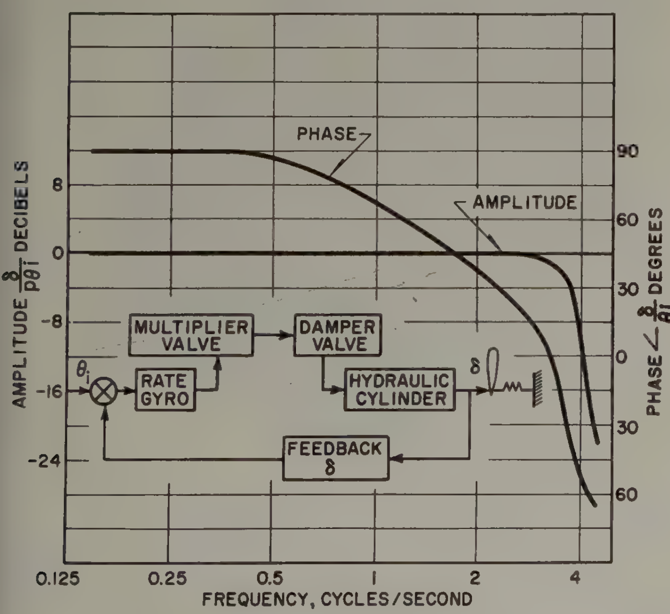
Equation 7 gives the aerodynamic torque $H_r\delta_r$ on the rudder as equal to two autopilot hinge moments $R_rp\psi$ and $R_\psi\psi$, operated on by the transfer function $Y_1(p)$. These two hinge moments are proportional to the yaw velocity and the yaw angle respectively.

The aerodynamic torque on the ailerons, $H_a\delta_a$, in equation 8 is opposed by the three automatic pilot hinge moments operated on by the aileron boost transfer function $Y_2(p)$. These three hinge moments are proportional to the roll velocity $p\phi$, the yaw velocity $p\psi$, and the side-slip angle $\beta$ respectively.

## STABILITY CALCULATIONS

The stability and transient behavior for both longitudinal and lateral motions can be calculated from the preceding equations. Using the numerical values of an early experimental application to the *F82* airplane as a typical example, the characteristic equation of the longitudinal system in operational notation is

$$p^6+26.8p^5+475p^4+5{,}920p^3+7{,}550p^2+5{,}930p+1{,}182=0 \tag{9}$$



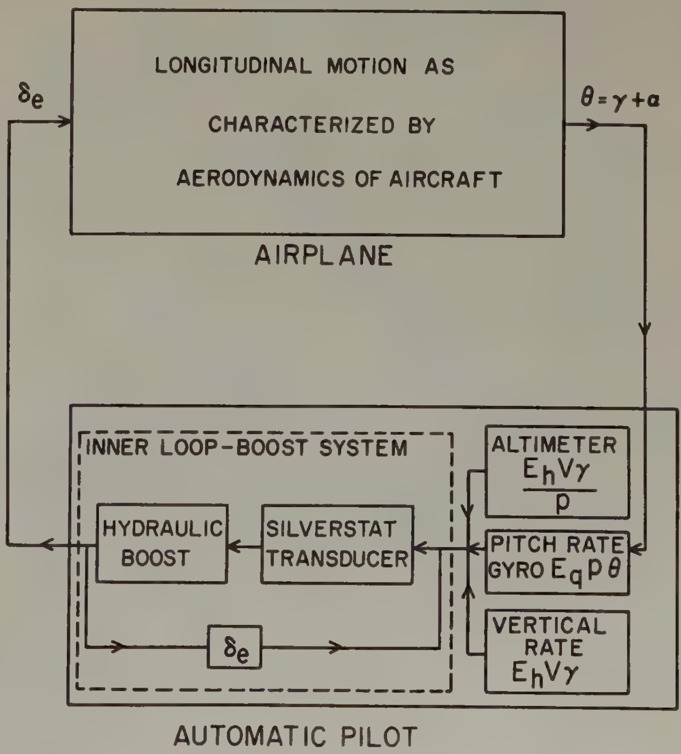
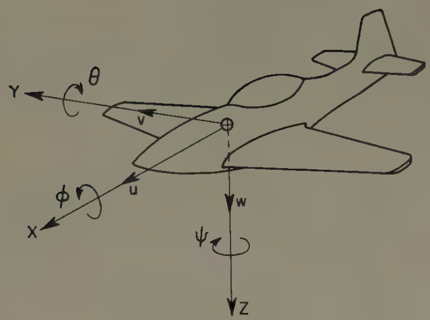




**Fig. 3 (above). Frequency response of rudder and elevator servo**
**Fig. 4 (right). Block diagram of longitudinal control system**




*X*—Axis: In plane of symmetry and perpendicular to *Z* axis
*Y*—Axis: Perpendicular to the plane of symmetry
*Z*—Axis: In plane of symmetry and perpendicular to the relative wind

*Positive Directions Are Shown by Arrows*

| Axis Designation | Force Along Axis | Moment About Axis | | Angle | | Velocities | |
|---|---|---|---|---|---|---|---|
| | | Designation | Positive Direction | Designation | Definition | Linear Along Axis | Angular About Axis |
| *X* Longitudinal | *X* | *L* Rolling | *Y*→*Z* | $\phi$ Roll | $\int p\,dt$ | *u* | *p* |
| *Y* Lateral | *Y* | *M* Pitching | *Z*→*X* | $\theta$ Pitch | $\int q\,dt$ | *v* | *q* |
| *Z* Normal | *Z* | *N* Yawing | *X*→*Y* | $\psi$ Yaw | $\int r\,dt$ | *w* | *r* |

**Figure 5. System of axes and symbols**

The application of Routh's criterion for stability to this equation shows the system is stable for longitudinal motions.

Equation 9 can be factored as follows:

$$(p+17.6)(p+0.28)(p^2+1.08p+0.797)(p^2+7.84p+300.7)=0$$

to yield the roots:

$\lambda_1=-17.6$; $\lambda_2=-0.28$; $\lambda_{3,4}=-0.54\pm i0.71$; $\lambda_{5,6}=-3.92\pm i16.9$

The oscillatory modes $\lambda_{3,4}$ and $\lambda_{5,6}$ show the following damping and frequency characteristics:

| | $\lambda_{3,4}$ | $\lambda_{5,6}$ |
|---|---|---|
| $f$ | 0.113 | 2.69 |
| $\zeta$ | 0.6 | 0.226 |
| $T_{1/2}$ | 1.28 | 0.177 |

The high-frequency oscillatory mode shown by $\lambda_{5,6}$ approximates that of the automatic pilot boost system which has a natural frequency of 3.2 cycles per second and a damping ratio $\zeta = 0.6$.

The lower frequency oscillatory mode shown by $\lambda_{3,4}$ has a correspondence to the oscillation of the airplane by itself. This latter mode can be found in the characteristic equation of the longitudinal system obtained from equations 8 and 9 which characterize the airplane.

The combined equations 4, 5, 6, 7, and 8 for lateral motion using the same *F82* airplane as an example give the following eighth order characteristic equation:

$$p^8+31.4p^7+620p^6+4{,}850p^5+24{,}600p^4+49{,}400p^3+82{,}300p^2+35{,}700p+4{,}575=0 \quad (10)$$

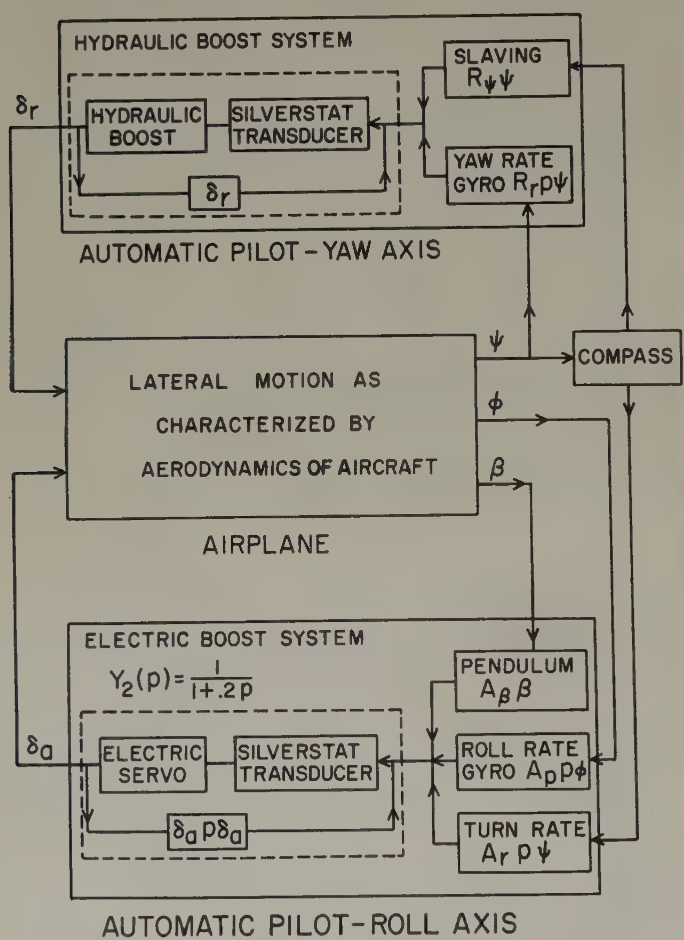



**Fig. 6. Block diagram of lateral control system**

**Fig. 7. Flight controller**

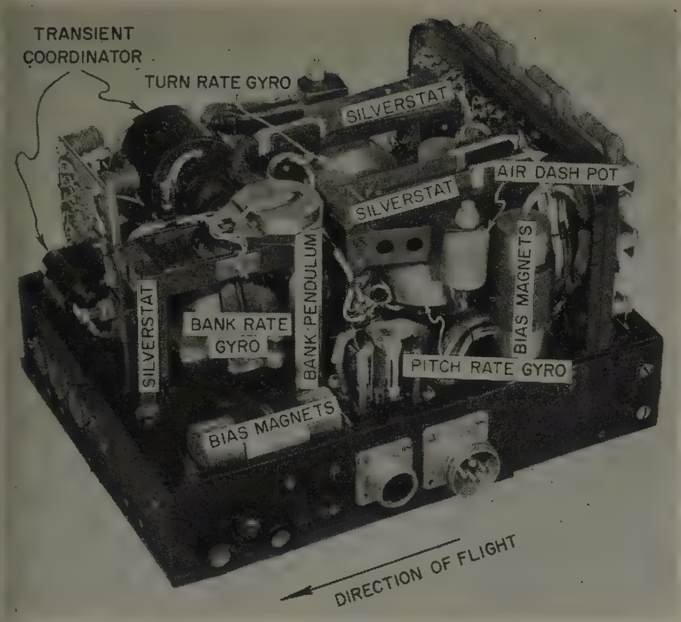



**Fig. 8. Gyro control unit**

This equation is interesting in that it has no real roots but four complex roots indicating oscillatory modes which cover a wide frequency range.

Equation 10 can be factored as follows:

$$(p^2+0.537p+0.0745)(p^2+1.58p+4.2)(p^2+7.4p+39.7)(p^2+21.9p+351.3)=0$$

to yield the roots:

$$\lambda_{1,2}=0.268\pm i0.05;\ \lambda_{3,4}=-0.79\pm i1.89;\ \lambda_{5,6}=-3.7\pm i5.1;\ \lambda_{7,8}=-10.9\pm i15.2$$

These roots give the following actual frequencies and damping characteristics:

| | $\lambda_{1,2}$ | $\lambda_{3,4}$ | $\lambda_{5,6}$ | $\lambda_{7,8}$ |
|---|---|---|---|---|
| $f$ | 0.008 | 0.3 | 0.81 | 2.42 |
| $\zeta$ | 0.98 | 0.385 | 0.588 | 0.583 |
| $T_{1/2}$ | 2.58 | 0.877 | 0.187 | 0.0635 |

It will be noted that all oscillations which can occur in the lateral system are damped adequately. The roots also show a rapid decay to half-amplitude which has been taken as a damping criterion. The long period root $\lambda_{1,2}$ is a Dutch Roll type of oscillation with a 125-second period and its high damping is the result of cross-feeding the yaw rate into the aileron control system. If this cross-feed is omitted, $A_r p\psi$, and the characteristic equation is calculated for the lateral system as in the foregoing (also neglecting the delays of the automatic pilot which are small compared to the Dutch Roll period), the following fifth-order equation is obtained:

$$p^5+10.1p^4+23.1p^3+39.2p^2+5.8p+2.29=0$$

which factors into the following:

$$(p+7.77)(p^2+0.125p+0.065)(p^2+2.2p+4.56)=0$$

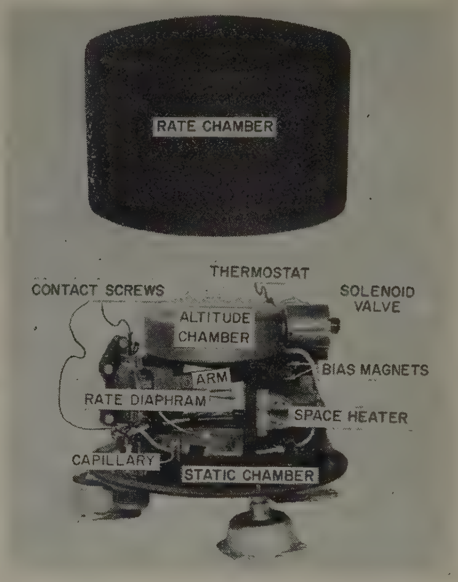
The quadratic factor $p^2+0.125p+0.065$ contains the long period root in this case and shows a damping ratio $\zeta = 0.244$. The time to damp to one-half amplitude is 11.1 seconds or about four times longer than when the yaw rate into roll cross-coupling term was included.

It is beyond the scope of this article to give a complete analysis of the aircraft–automatic pilot system. Once the basic equations have been developed, it is not difficult to investigate the effects of changing parameters.

## SYSTEM COMPONENTS

The flight controller, whose general functions have been described, is shown in Fig. 7. Small synchronizing motors are located in this unit to position the single control knob when the autopilot is in a stand-by configuration.

**Fig. 9. Altitude-rate control**



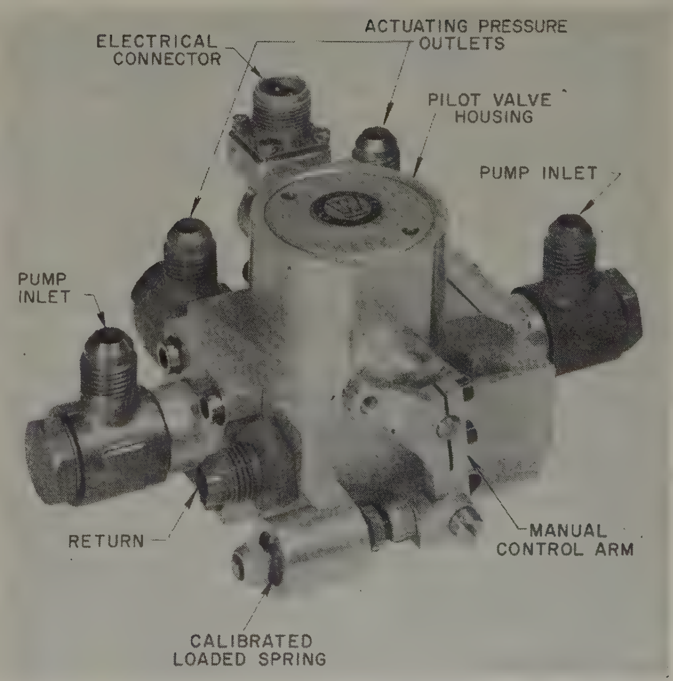




**Fig. 10. Electromechanical hydraulic multiplier valve**

This positioning insures that the aircraft will maintain its existing flight path when the automatic pilot is engaged.

The gyro control unit, Fig. 8, contains three rate gyros properly oriented to respond respectively to the angular velocity of the aircraft about its vertical, longitudinal, and lateral axes. The Silverstat transducers, biasing magnets, bank pendulum, and transient co-ordinator also are located in this unit. The rate gyros with their transducers require an angular deflection of less than one-half degree for full output signal. Therefore, it is not difficult to obtain a frequency response of 15 or 20 cycles per second with these components.

The altitude-rate control, shown in Fig. 9, supplies signals to the bias coils of the pitch-rate gyro to maintain level flight or a fixed rate of climb or dive as determined by the flight controller. The air pressure within the rate chamber differs from the static pressure by an amount proportional to the rate-of-climb or dive. This device will respond to vertical rates in the order of a few feet per minute with a time delay of less than one second. A small altitude chamber, located inside the larger rate chamber, is used to measure departures from a fixed pressure altitude and supply an output signal proportional to the error. Altitude changes in the order of 3 feet will give an error signal. A small solenoid-operated valve is used to open this chamber and remove its signal whenever a fixed altitude is not required.

In the past one serious limitation to adding an autopilot to an actual air frame has been the requirement of using the existing boost system. These systems, which are hydraulically operated on most high-speed airplanes, usually are designed with no thought of the requirements of an automatic pilot. The backlash and time delays ordinarily associated with the relatively large travel of spool-type valves make it difficult to meet the requirements of a high-performance automatic-control system. To overcome this difficulty, the electromechanical hydraulic valve shown in Fig. 10 was developed. This is a 2-stage multiplier valve which can be used for both manual and automatic control. A manual control arm provides for mechanical operation from the existing boost system while a small internal torque motor furnishes the electrical coupling for control by the autopilot. A servo valve of this type is capable of controlling several horsepower with only a fraction of a watt input power.

## FLIGHT TESTS

The first flight tests of the rate-gyro system on fighter-type aircraft were made using the *F82* airplane. This is a twin-engine, twin-fuselage, long-range fighter and was selected on the basis of availability and its dual controls. A flight controller for the autopilot was installed in each fuselage.

In the "boost" configuration the pilot was able to fly the airplane in any maneuver using the single control knob to regulate independently the velocity about each axis. The increased damping, furnished by the rate gyros, was found to be of considerable assistance in some maneuvers. For example, the *F82* requires a good degree of co-ordination between rudder and elevators to maintain direction of flight when making a manual roll. Rolls made with the rate autopilot required only a displacement of the control knob about its longitudinal axis. In this case the yaw and pitch gyros are calling for zero angular rate and their precession is of the correct magnitude and direction to help maintain the flight path.

The several system frequencies and their damping ratios as shown in the foregoing calculations were found to be in general agreement with those observed during flight tests.

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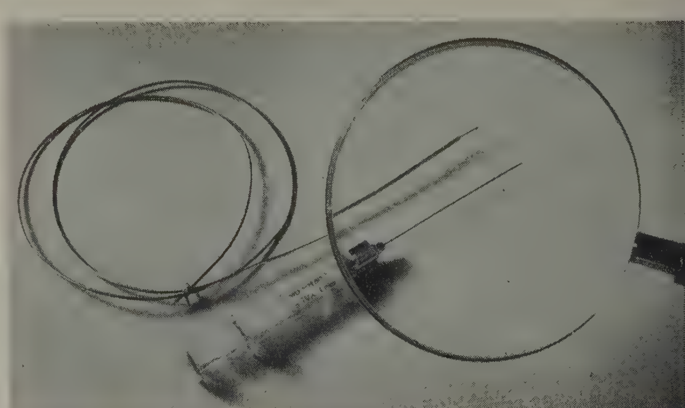
3. Gyroscopes and Their Applications, **K. A. Oplinger.** *Westinghouse Engineer*, Pittsburgh, Pa., vol. 8, May 1948, pp. 75–9.


# Thermocouple Measures Temperature Inside Nuclear Reactor Fuel

A uniquely designed thermocouple, developed at Argonne National Laboratory, makes possible temperature measurements inside the fuel elements of operating nuclear reactors. This is possible because the new thermocouple is only slightly thicker than a standard hypodermic needle. Because of its thinness, flexibility, and ruggedness it can be threaded through small and winding passageways into places not reached by conventional thermocouples.

Construction of the thermocouple consists mainly of inserting a thin insulated constantan wire into a small diameter inconel tube and drawing the tube through a die on a draw-bench, thereby tightly gripping and sealing the wire within the tube.

Thermocouples which are 0.040 inch in diameter and 20 feet in length have been constructed and used to detect and record temperatures up to 1,250 F.



**Comparison of thermocouple to a standard hypodermic needle. Magnified portion shows the lead end of 0.040-inch-diameter inconel thermocouple tube into which a 0.015-inch constantan wire has been inserted. Diameter of needle is 0.025 inch**

# Lightning Surges on Overhead Distribution Lines

R. H. GOLDE
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LIGHTNING FAULTS on high-voltage transmission lines are due exclusively to direct strokes to the line. Faults on distribution lines operating below 33 kv may be caused in addition by indirect strokes which strike the ground near the line or which contact an earthed (grounded) part of the line without causing back flashover.

As can be inferred from Fig. 1, the amplitudes of indirect lightning surges increase with increasing intensity of the inducing lightning current, but the rate of increase is less than proportional. On a line employing 40 foot-poles the maximum amplitude of indirect surges is found to be about 300 kv, but this amplitude is reduced greatly if the line is surrounded by tall conducting objects such as buildings or trees. Indirect lightning surges have a roughly double-exponential waveshape, the length of which increases with increasing amplitude of the inducing lightning current and increasing distance between flash and line. The maximum front steepness is about 60 kv per microsecond although values of 20 kv per microsecond are not frequently exceeded.

Fig. 2 shows the calculated frequency of occurrence of flashover for typical British 11-kv lines traversing open country. As a result of rival attractive effects, a line surrounded by trees is liable to be subjected to only about half the number of flashovers indicated in Fig. 2. While lines on wood poles may sustain considerably fewer flashovers than lines with earthed poles, the former support a higher number of surges below the flashover level of the line and thus require special lightning protection for terminal equipment. On the other hand, even at 11-kv operating voltage, a line with overrunning earth wire should give better results than any other type of line construction, provided the footing resistance at each pole is kept below about 20 ohms and the impulse level of the line above about 100 kv. On all types of earthed line the number of flashovers decreases rapidly with increasing impulse level of the line insulation. On lines crossing high-resistivity territory an earth wire below the phase conductors is particularly effective in reducing the number of flashovers if the impulse level of the line is high. On lines with overhead earth wire, flashovers caused by direct strokes greatly outnumber those due to indirect lightning surges, whereas on lines without earth wires but with earthed poles indirect surges may cause more flashovers than direct strokes, at least for lines with low impulse level. An arc suppression coil therefore should prove more effective on a line with high than with low impulse level, and on a line with earth wire should give better results than on a similar line without earth wire.

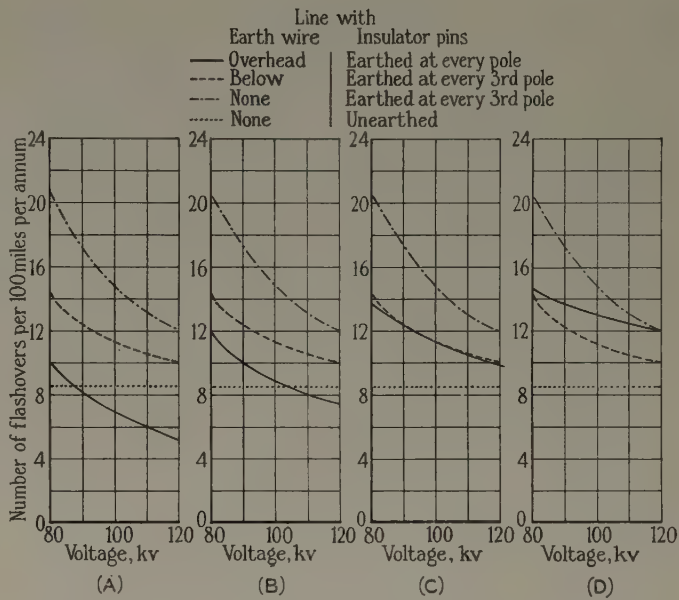


**Fig. 2. Variation of number of flashovers with impulse level of line**

*Pole footing resistance*
*A—10 ohms; B—20 ohms; C— 40 ohms; D—100 ohms*

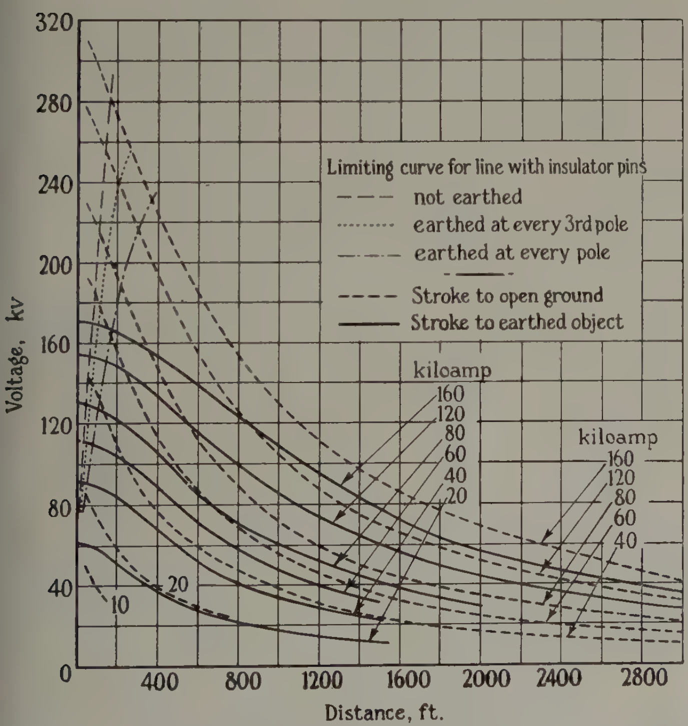


**Fig. 1. Variation of indirect surge amplitude with distance between lightning stroke and line. Overhead line with no earth wire**

Digest of paper 54-4, "Lightning Surges on Overhead Distribution Lines Caused by Indirect and Direct Lightning Strokes," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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# Corrosion Control of Underground Power Cables

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MEMBER AIEE

CORROSION OF underground structures is basically an electrochemical process which conforms to Faraday's law of electrolysis. In anodic areas, current discharge from cables and pipes results in electrolytic corrosion at the annual rate of 75 pounds of lead or 20 pounds of iron loss per ampere discharged. Where the emf is external to the cables the corrosion cells may be caused by stray currents from d-c systems such as railways, or by electric connection of the lead cable sheath to more noble metals. Where the emf is internal to the cable sheath, corrosion cells usually result from exposure of the cable to an electrolytic environment in which variations exist in soil aeration, moisture, salt content, and texture. Soil bacteria probably are influential in causing differences in aeration in the soil and duct mud and thus generating a corrosion cell.

Effective control of cable sheath and pipe corrosion is obtained by a program of electrolysis surveys and tests and the design and installation of mitigative equipment and measures. Periodic testing also is required for supervision of the operation of the mitigative measures.

The locations of corrosive areas can be determined by exploring a vacant duct of a partially occupied cable duct bank with a test probe consisting of the equivalent of a 1-foot length of cable. With the probe placed at various positions in the duct, measurements of potential difference, current, and resistance are made with electric instruments connected between the test probe and the cables in the splicing manholes. The potential difference measurement indicates whether the operating cable near the test point is anodic or cathodic, and whether the magnitude of the emf of the corrosion cell is fluctuating (e.g., stray railway current) or steady (e.g., galvanic current). The magnitude of the current flowing between the operating cable and the test probe indicates the rate of corrosion. The resistance measurement gives a clue to the relative area of the cable sheath in contact with the duct water and mud, and hence an approximation of the area of the lead sheath from which the current is discharged. As the result of experience with duct surveys made at corrosion areas, it is possible to estimate the expected life of the cable from the electrical measurements.

Despite the virtual abandonment of trolley lines in New York City, stray railway currents are still a potential corrosion factor as indicated by the need for draining 5,500 amperes of stray current from the cable sheaths to the rapid transit systems at 110 locations. Cathodic protection using rectifiers and anodes has been applied at several locations to mitigate corrosion caused by soil conditions. The anode may consist of scrap rail or pipe buried in the earth adjacent to the duct bank, or scrap lead-sheath cable pulled into a vacant duct. Protective coatings of neoprene over the lead sheath of new cables have proved satisfactory in very corrosive areas. The application of a petroleum grease during installation of new cables has been successful in other corrosive areas.

During recent years, the problem of corrosion protection of the newer pipe-type cable system has been given attention. The application of cathodic protection to the pipe is complicated by the need to maintain electrical continuity and grounding of the steel pipe. Development of new methods of cathodic protection, therefore, seems to be indicated.

In order to reduce corrosion of the 25 pipe-type cable installations in New York, an asphalt mastic coating is applied to the steel pipe at a coating plant. Following assembly by welding of the individual lengths, the welds are coated and the entire coating is thoroughly spark-tested for defects which then are repaired. The insulation resistance of the coated pipe is measured immediately after backfilling and annually thereafter when the feeder is disconnected from the busses. A gradual decrease in coating resistance appears to be caused by moisture absorption.

When sharp decreases occur in the coating resistance an electrical over-the-ground survey is made to locate coating defects which then are repaired. In case of metal-to-metal contacts between the buried feeder pipe and surrounding metallic structures the point of contact is found by means of an audio-frequency tone, pickup coil, and earphones.

In order to maintain the pipe potential negative with respect to the earth, a 2-volt storage battery has been installed in series with the ground connection at each end of the pipe. Although the 2-volt negative potential of the pipe safeguards the pipe from corrosion, there are disadvantages which can be overcome by other methods of cathodic protection such as by a 0.3-volt step voltage from a current-carrying resistor which is in the ground connection.

While existing test methods are satisfactory for stray current electrolysis and galvanic corrosion caused by dissimilar metals, they are inadequate in estimating the severity of corrosion by soil corrosion. Since lack of soil aeration is one of the primary factors in causing electrolytic soil cells, greater attention should be given to quantitative determination of soil aeration or the reduction-oxidation potential of the soil. The soil redox probe designed by Starkey and Wight appears to be suitable for measuring the corrosiveness of wet soils but requires further development for use in dry or moist soils.

Digest of paper 54-77, "Corrosion Control of Underground Power Cables in New York," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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# Graphic Analysis of Communication Networks

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**This system of graphic analysis and notation was developed with the goal of establishing a uniform set of network illustrations which could be used in analyzing the operating characteristics and faults of the network. Although it now has been in use about 2 years, only one change has been made in the original legend to avoid ambiguity and two new symbols added for recently incorporated equipment.**

IN THESE days with an ever-expanding necessity for communications, control circuits, and other channels for the transmission of intelligence, it has become apparent in all industries confronted with special communications problems that a suitable system for delineating and illustrating complex communication networks is to be desired. Such a system of illustration requires a fundamental analysis of the developmental stages of a general communications network as a whole.

In the case of most communications networks, development was gradual and it became necessary first to establish what might be called single-line networks between two points. In the case of large power utilities, such a network may have originated in the construction of a single metallic telephone line from a particular plant or property to a central point of control for this individual plant.

This elementary network generally consisted of nothing more than two or more magneto telephones terminating either end of the metallic telephone circuit, and was used for dispatching information from the plant to the point of central control and vice versa. In the development of additional plant projects, taps, legs, and junctions encroached upon the original 2-terminal line, thus forming a private network consisting of many terminals. It can be seen that further development along this line was predicated on the economic necessity of establishing a single communication facility for each such plant development. After a series of such developments, and over a period of years, highly complex networks were evolved in which different standards and nomenclature have been used to delineate the various sections and elements of the network, because a uniform set of symbols was not available for use in recording these system developments.

The power industry as a whole has accepted a standard code of symbols which are sponsored by the AIEE, and accepted as American Standards, distributed by the following designations:

(*Z32.3*) "Graphical Symbols for Electrical Power and Control," issued March 1946.

(*Z32.5*) "Graphical Symbols for Telephone, Telegraph, and Radio Use," issued October 1944.

These graphical symbols sponsored by this organization are applicable for the most part to single-line analysis of complex power networks and, in so far as possible, have been incorporated in the development of the group of symbols discussed in this article. There has been, however, a very pressing need for a special group of symbols for the communications industry as a whole. The symbols that have been accepted as standards for "Telephone, Telegraph, and Radio Use" lend themselves particularly to manufacturing and equipment detailing; unfortunately these symbols do not attempt to include such elements as are found necessary in the illustration of communications networks.

The symbols presented in this article have been reduced to the simplest number of available network elements that have proved themselves to be consistently necessary in the

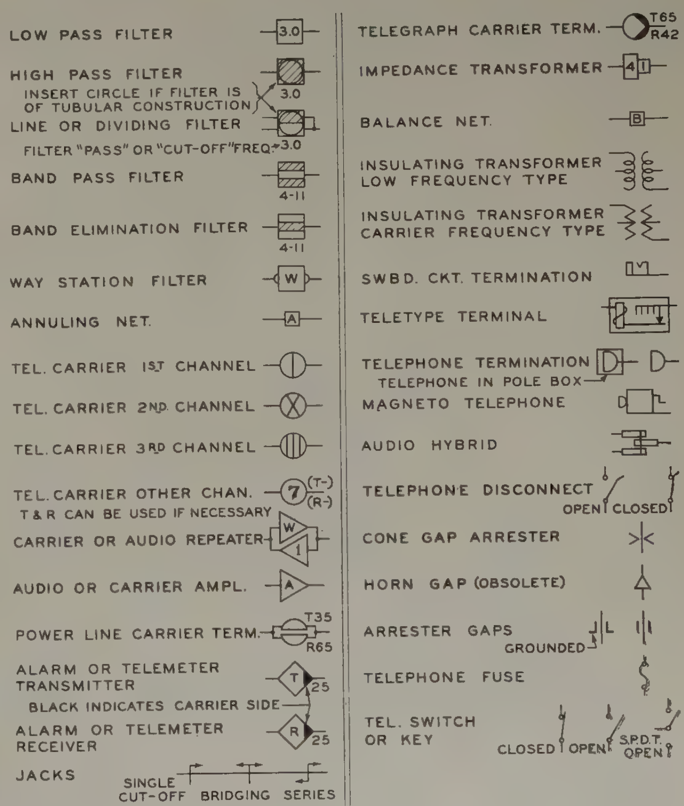


**Fig. 1. Legend of communication symbols**

Full text of a conference paper presented at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953, and recommended for publication by the AIEE Committee on Carrier Current.

**R. L. Mayer** is with the Pacific Gas and Electric Company, San Francisco, Calif.

analysis and description of a well-developed operating communications network.

The original development of these symbols, shown in Fig. 1, came about in the natural course of plant expansion in utility communications systems. The network to be analyzed consisted of approximately 8,000 miles of open-wire line built on power structures, and privately owned telephone poles, cables, and some leased circuits. Some 50 channels of carrier equipment and over 100 channels of control, alarm, and telemetering equipment made up the major portion of the network.

During the growth of this communications system, the maintenance and operation of the network was supervised by the electric system dispatchers. When supervision became a tremendous additional load to the power dispatching personnel, it was deemed advisable to institute a "wire chief" whose duties would be to supervise the operation of the communications network. In so doing it further became apparent that it would be necessary to supply this wire chief, as well as other operating and supervising personnel, with a uniformly coded graphic system for illustrating, recording, and analyzing the operating characteristics, as well as the faults on the co-ordinate communications network. A wealth of material was available with respect to individual wire-line circuits but little or no information had been distributed generally with regard to the more complex existing circuity. The system of graphic analysis and notation described in this article was developed towards the end of establishing a uniform set of network illustrations which could be used in analyzing the operating characteristics and faults of the network.

Further requirements for communication facilities predicate the use of carrier equipment as well as phantom circuits and simplex signal circuits in order to derive more communication channels after a basic communications network, in a physical-plant form, already exists. This has been the established pattern in the field of private communications as well as commercial communications networks. The inclusion of these complex methods for obtaining individual channels without the extension and construction of basic outside plant has caused the communications network as a whole to increase in complexity by a ratio considerably greater than the direct ratio of installed elements. It is a network of this nature which contains a fully developed plant of wire lines, radio, phantom, simplexed, composites, and carriers of various types upon which this system of graphical analysis was based and applied.

The problem to be considered in the design and establishment of a group of delineating symbols could be considered in the light of the particular medium of propagation of intelligence that is to be illustrated. These media in respect to a developed system would consist of the open-wire plant, cable, radio-circuits, and secondarily to the particular facilities to be employed. These might be subdivided into a group consisting of the modes of transmission, namely, telephony, telegraphy, carrier telephony, carrier telegraphy, carrier alarm, simplex, phantoms, and composite circuits. Therefore Fig. 1, which is a simplified legend of symbols, has not definitely indicated any of the described systems of propagation but contains a legend that is applicable in the most part to all of these systems as general symbolic nomenclature.

## DEVELOPMENT OF ELEMENTARY SYMBOLS

THE DEVELOPMENT of the symbol elements in Fig. 1 have been arranged in so far as possible to represent the actual network elements which would be applied in most cases. The legend itself represents a sequence of basic elements in accordance with their general importance and usages. The six basic filters used in the primary divisions of carrier circuity are illustrated first. A method for the illustration of individual channeling equipment is shown next. In the case of most carrier communications networks where frequency division systems of some complexity are employed, it does not appear to be of primary importance that the actual frequency spectrum employed in each channel be illustrated in a primary analysis of the network. Therefore a circular symbol of a 2-terminal network has been adopted, incorporating easily defined lines to divide the three prime channels of carrier that might be applied first to a particular line. In an effort to simplify further, all other

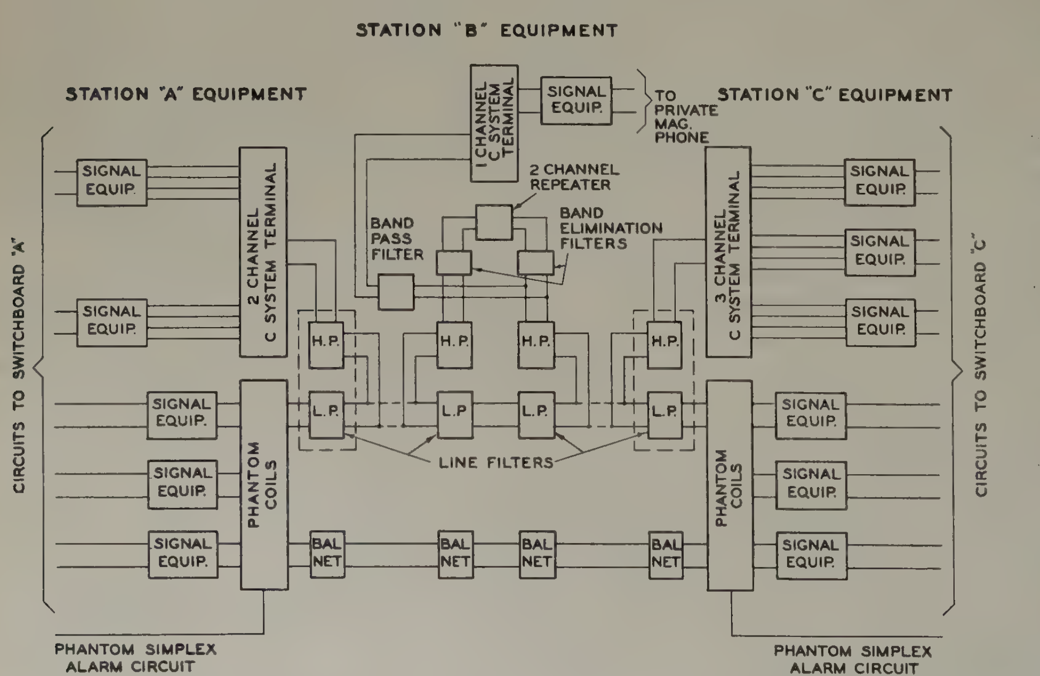


Fig. 2. Typical representation of communications system as used by various services

channels above the order of the third are indicated by a similar 2-terminal symbol incorporating only a number which signifies the particular channel in a fully developed multichannel group.

Generally speaking, almost all systems of carrier equipment manufactured and available commercially at the present writing follow a published scheme of frequency-division, or time-division. It therefore does not appear advisable to incorporate these spectrum notations along with the carrier channel symbols but rather to assume that these definitions are well known. Representation of phantom and simplex circuits was deemed advisable because of the fact that even in present-day communications there is a tendency towards the use of phantomed circuits, particularly where an established plant already exists in the form of two balanced telephone lines between two points. The dictates of economy make it mandatory that an additional circuit be derived by an inexpensive and suitable method such as the formation of a phantom group, by the simple addition of six repeating coils.

In the past, circuitry of the phantom type has been difficult to illustrate in a single-line diagram suitable and compatible with the analysis of either straight wire lines or carrier circuits. After some experimentation it was decided that the transformers or repeating coils could be illustrated in a manner compatible with other single-line graphic representation. This however presented a problem due to the fact that a single-line representation lends itself only to the use of 2-terminal graphic symbolism, if directional understanding is to be maintained. We therefore have developed a symbol for a coil of this type which becomes a single-line symbol, and which can be expanded to become a 4-terminal instead of a 2-terminal network.

It can be seen in Fig. 3 that the development of this particular graphic representation of the repeating coil is the essential cause of simplification in the phantom group with applied carriers, illustrated in conventional graphic form in Fig. 2, and in its simplified form in Fig. 3.

The representation in Fig. 3 is designed also to present an exaggerated simplification of a somewhat complex communications system in an effort to stress the clarity that can be achieved in delineation of such a system, when it is no longer necessary to label and letter the component parts in order to represent the network.

One immediate reaction to an entirely new system of representation, when presented along with the usual type of representation, is to believe that the simplified form is completely incompatible when presented by itself, and that to be understood it would be necessary that any drawing using the simple form of symbols be accompanied with a legend. This of course would be the case were this system to be used to explain network connections and elements to the completely uninitiated, or in the case of a manufacturer attempting to illustrate a system to a prospective customer. However, the system was not developed with either purpose in mind, but for distribution to field personnel to acquaint these people with the desired system of symbol notation. In order to solve this problem, and expedite understanding of the new symbols, a photo-reduction of the symbols in Fig. 1 was made, and from this an inexpensive photolithographic

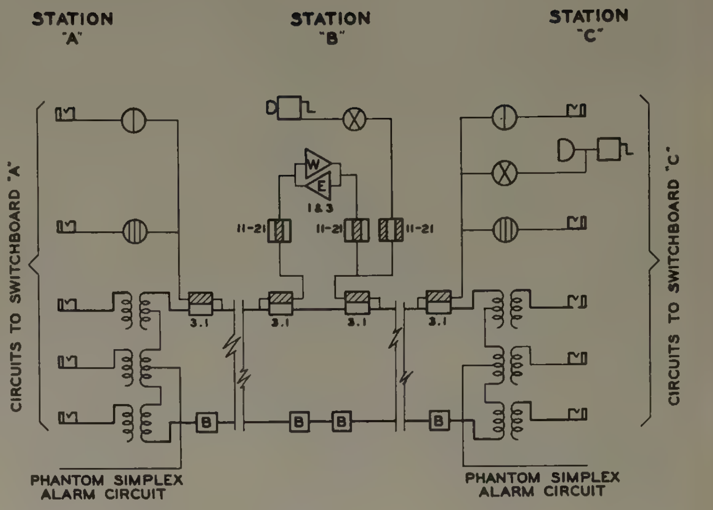


**Fig. 3. Representation of system shown in Fig. 2 utilizing the symbols shown in Fig. 1**

plate was made. The plate then was used to print copies of the legend as illustrated in Fig. 1, the copies being printed on gummed paper stock, to a finished size of 4 by $4^1/_2$ inches. These "stickers" then were attached to all prints sent into the field and proved most successful in providing the necessary legend needed for interpretation, obviating the necessity of the draftsman spending valuable time drawing a separate legend on each drawing.

The representation in Fig. 3 is designed to illustrate the usage of "coded lines" to indicate a variation in physical plant construction. The broken lines are symbolically "cable circuits," while the solid lines are used to represent "open-wire plant." This necessity is apparent, particularly in the analysis of circuit attenuation caused by impedance irregularities which occur in many cases as the direct result of using and interconnecting cable and open-wire facilities with their inherent differences of impedance. The existence of these impedance irregularities has required the use of a symbol such as the impedance transformer shown in Fig. 1.

The illustration of such an impedance transformer was excluded in the representation shown in Fig. 3, because it was quite obvious that there was no room for illustrating such a symbol in Fig. 2. It is quite noticeable, however, that it would present no problem to insert this particular symbol in a representation of a network such as that shown in Fig. 3 which is of course the simplified analysis of the exact network shown in Fig. 2.

## VARIATIONS AND EXCEPTIONS

Examination of the symbols shown in Fig. 1 (telephone carrier channels 1–7, carrier or audio repeater, power-line carrier terminal, telegraph carrier terminal, and Teletype terminal) will show that they have been illustrated as 2-terminal networks. Therefore, all the telephone carrier channels, for instance, could be assumed to be operated as duplex channels and by the same token the Teletype, or telegraph terminals would be assumed to be always operated as a half duplex. This, however, is not the case, as these symbols have been so drawn that the transmitting and receiving sides can be shown separately.

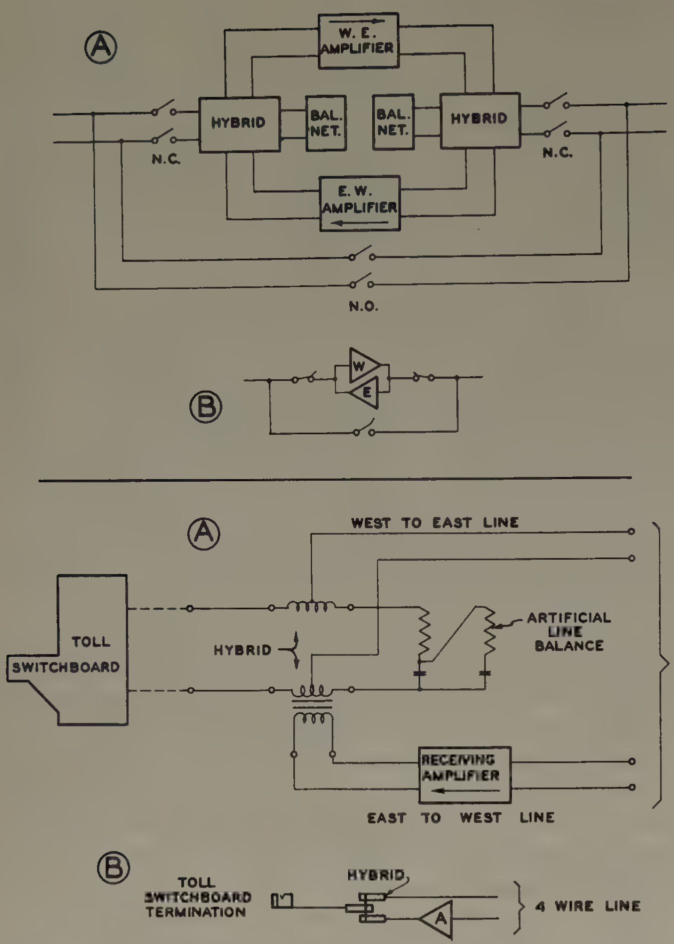


**Fig. 4. Two examples of simplification obtained by use of graphical symbols shown in Fig. 1. Above—Audio-telephone repeater; Below—termination of 4-wire amplified line**

The symbols for communications circuit protective devices, shown in the lower right-hand section of Fig. 1, may not be considered as necessarily essential in the analysis of a general communications network, however in the practical application of these symbols it was desirable to incorporate them. The addition of an angular end to the "telephone disconnect switch" shown in Fig. 1 obviated the necessity of including such lettering as N.O., N.C., O.N, and S.—Normally Open; Normally Closed; Off Normal; and Solid. This type of initialed indicators has always led to some confusion in the understanding of foreign drawings. By the use of a disconnect switch symbol, as shown in Fig. 1, this confusion no longer exists, and the drawing then shows the "operating condition" of the specific switching element. The upper illustration in Fig. 4 illustrates this application. The lower illustration of Fig. 4 shows the possibilities of simplification obtainable with the use of three symbols.

CONCLUSION

To test the application of this group of symbols a project was initiated early in 1951 to illustrate a particularly complicated branch of an existing network and reduce it to the simplest possible representation. This particular test line consisted of 210 miles of number 8 copper-wire paired line constructed for the most part on twin 110-kv steel transmission towers, with several underground and aerial cable sections and crossings, submarine river crossings, wood pole "take-offs", and loops into various way stations. The line also was chosen for study because it has superimposed upon it 8 carrier channels of telemetering and alarm in the frequency spectrums between 25 and 100 kc, 3 channels of voice-carrier were superimposed incorporating the frequencies between 4 and 31 kc. Simplex-to-ground water-level alarms existed over small intermediate sections of the line, on a d-c basis, as well as a power-line carrier-type repeater and three power-line carrier-type 2-terminal systems in the frequency spectrum from 45 to 99 kc. All of this equipment is used simultaneously on one pair of wires. The physical-line also is operated for "party-line" communications, and incorporates some 30 way stations with taps extending up to 14 miles in length. From this it can be seen that the test problem for the application of these graphic symbols was indeed a problem of manifold elements in the graphical treatment of a complex communications network.

The treatment of this line and its consequent reduction to practice in analysis was accomplished with surprisingly little difficulty, and only minor changes were required in the legend of symbols that were developed at that time.

Since the initial problem was undertaken and successfully solved, numerous other lines have been analyzed and recorded by the use of these graphical symbols. In about 2 years of use, and and after due consideration, in an effort to perfect a universal group of symbols only one change has been made in the original legend. That change was made to eliminate the possibility of ambiguity of two of the incorporated symbols.

The recent incorporation of Teletype equipment into the communication network has required the addition of two symbols which were not incorporated in the original legend. These are the symbols for the telegraph carriers and the symbols for the Teletype keyer-printer combination.

## Radio Control of Airport Lights

The Radio Technical Commission for Aeronautics (RTCA) is investigating the feasibility of remote control operation of field lights at airports which are unattended at night.

The operation of airport lights by aircraft radio has been tested in preliminary experiments by one air line which utilizes some smaller airports. A number of problems must be resolved, however, before an effective remote control lighting system can be established. In the tests that have been conducted, a radio receiver to which a suitable switching mechanism had been connected was installed at the airport. The approaching pilot turned on the airport lights by pressing the microphone switch of his aircraft transmitter a predetermined number of times. The lights were extinguished by similar action after take-off. Such a system could become an important safety factor by increasing the number of landing fields available in emergencies.

# Contactor Servomechanisms Employing Sampled Data

C. K. CHOW

A SINUSOIDAL RESPONSE method of analysis and synthesis of a contactor servomechanism employing sampled data in the error channel is introduced. Fig. 1 shows the block diagram of the particular servo system under investigation. Due to the presence of the sampler, clamper, and contactor the system is discontinuous in time as well as being nonlinear. An exact system performance can be obtained only by laborious computations, moreover, no exact analytic solution in closed form can be obtained. However, much can be learned about the system by employing a sinusoidal response technique. Although an approximate method, the sinusoidal method provides a useful guide in analysis and synthesis.

*Assumptions.* In the investigation it is assumed that all parts of the servo system except the sampler, clamper, and contactor are linear and the sampling rate is uniform. For simplicity, only the systems having at least one integration factor and the contactor possessing an operating characteristic as shown in Fig. 2 are considered. The treatment is based on nondimensionalized quantities.

The sampler, clamper, and contactor in cascade are lumped together and considered as a single nonlinear element. Its describing function is derived and can be represented on the complex plane by a family of regions, named critical regions; one region for each dimensionless period of integer value. The nonlinear element is essentially a variable phase-lag device.

By the superposition of the critical regions on the conventional g-locus of the linear part of the system, one is able to determine the conditions of occurrence of self-sustained oscillations and their amplitudes and periods and to evaluate the critical value of the dimensionless inactive zone of contactor.

Self-sustained oscillation can be prevented by using a dimensionless inactive zone of larger value than the critical value. The system also can be stabilized by employing a proper compensating network. The increase in the value of dimensionless inactive zone can be achieved by one or the combined effect of the following: (1) the increase of the actual inactive zone of the contactor, (2) the decrease of the over-all forward loop gain, and (3) the decrease of the sampling period.

*Accuracy of the Sinusoidal Method.* Electronic analogue computer techniques are employed to check the accuracy of the sinusoidal response method. The comparison of results for all cases investigated shows that:

1. The method exhibits no error in predicting the period of self-sustained oscillation.

2. The error in predicting the critical value of dimensionless inactive zone is, in general, within 5 per cent.

3. The error in predicting the amplitude of oscillation depends primarily upon the effectiveness of low-pass filtering action of the servo system. The more effective it is, the better the accuracy will be. In general, it is within 10 per cent.

*Accurate Prediction of Amplitude of Oscillation.* Based on the predicted value of period, the exact amplitude of oscillation can be evaluated by solving the linear differential equation relating the contactor output and system output, and by matching the end conditions at the discontinuities of the contactor output for one period of oscillation.

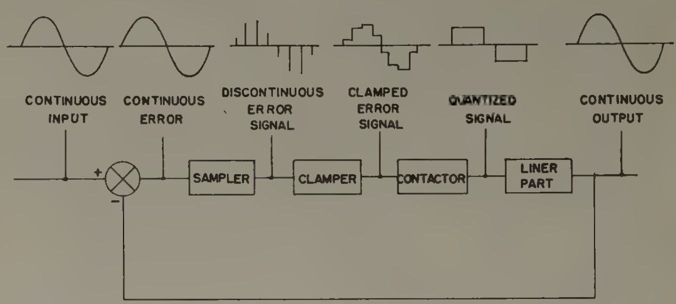


**Fig. 1. Block diagram of the servomechanism**

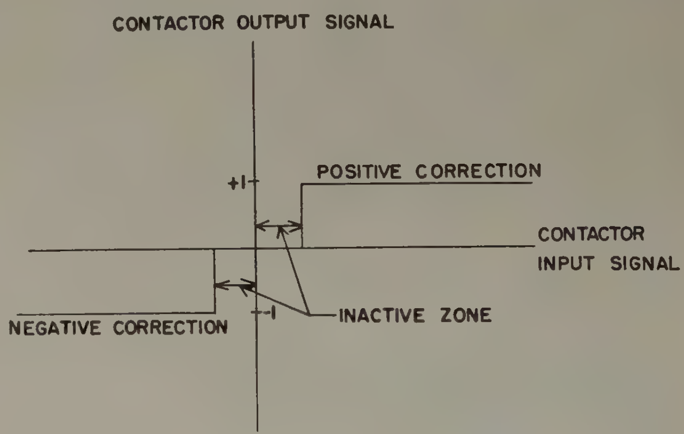


**Fig. 2. The operating characteristic of the contactor**


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# Functional Evaluation of Transformer Insulation

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IN THE PAST few years a strong trend has developed toward the evaluation of electrical insulation by functional testing. It seems generally agreed that (*a*) the present AIEE, *A*, *B*, and *H* temperature classifications are no longer adequate, and (*b*) functional tests rather than chemical structure alone should provide the basis for classification. For example, several recent AIEE papers have proposed various accelerated life test procedures for deciding whether a given material or system will have a satisfactory life expectancy at a continuous hot-spot temperature of 105, 130, or 180 C and, therefore, can be designated properly as Class *A*, *B*, or *H*.

To evaluate the insulation for small dry-type aircraft and electronic transformers or similar small equipment for which minimum weight and cost are prime requirements, the authors would suggest a slightly different plan from those that have been proposed so far. This plan would be different since the required life of these small units may be only 100 hours or so, or perhaps a year, and may vary widely for different applications. This is far different from the practice in designing large industrial apparatus, for which the AIEE insulation classes were originally established, where life expectancies of 10 to 30 years or more are customary.

Therefore, the authors suggest that insulation for small dry-type transformers be classified by means of functional tests that will establish separate normal life–temperature curves for each material and for each system. The curves for the materials would be obtained under prescribed conditions and would be applicable to all types of electric equipment. The curves for the systems would simulate closely those conditions expected in service. Their application would be limited to these particular systems. Designers should be free then to select any combination of materials and temperature rise best suited to the equipment, the service, and the desired life. Under this plan a given material no longer will be associated with a particular temperature. Instead, it may be defined by a temperature–life curve or possibly by a family of curves for different electrical or mechanical stresses.

Evaluation tests on an insulation material should be designed to give information in addition to its time–temperature behavior to determine whether it is suited for (*a*) separation, (*b*) dielectric barrier, or (*c*) physical support. This information would be useful equally to designers of small and large transformers alike. A detailed formulation of these tests would come more logically within the scope of such organizations as the American Society for Testing Materials.

Evaluation tests on insulation systems can be performed directly on small transformers or on an equivalent model. Such a set of tests is summarized in Table I as a proposed test code for aircraft and electronic transformers. It is intended that it require no unusual equipment or technique to perform. The principles suggested by it have been used by the authors over a 3-year period. The deteriorating effects of most service conditions are simulated by the simultaneous application of heat and dielectric stress and by the periodic check on the state of this deterioration by mechanical stress, moisture exposure, and dielectric stress. The data obtained from the use of the test code are planned to be used to establish the time–temperature behavior of the insulation system.

**Table I. Summary of Proposed Test Code for Small Dry-Type Transformers**

| Step | Test | Time, Hours | |
|---|---|---|---|
| 1 | Condition at 25 C, 25% relative humidity | 24 | First Cycle Only |
| | Dielectric stress | 5 sec/unit | |
| 2 | Heat age (use three groups of six transformers each; test each group at a different temperature) | 120–130 | |
| 3 | Determine hottest winding temperature | 3 min/unit | |
| 4 | Condition at 25 C, 50% relative humidity | 2 | |
| | Dielectric stress | 5 sec/unit | |
| 5 | Mechanical stress | 3 min/unit | |
| 6 | Condition at 25 C, 50% relative humidity | 2 | |
| | Dielectric stress | | |
| 7 | Expose to 100% relative humidity | 16 | |
| 8 | Dielectric stress | 5 sec/unit | |
| 9 | Condition at 25 C, 50% relative humidity | 2 | |
| 10 | Repeat steps 2 through 9 for each transformer until failure occurs | | |

The desirability of rating insulations by functional test has been widely demonstrated and accepted. However, much of the experience needed to adopt this kind of rating has yet to be acquired. Although it is believed that the tests will vary in kind and emphasis for different applications it still is essential that a test code be available to form a basis for the composition of the tests so that the accumulated experience can be most useful and so that the time when insulations can be classified by functional test will come sooner.

In summary it is believed that, in the formulation of a functional classification for insulations for transformers:

1. Test codes and standards for aircraft and electronic transformers and other short-lived apparatus should be developed independently of those for other dry-type and large transformers.

2. Evaluation of insulations should be conducted first as materials and then as systems.

3. Results of the evaluation tests on insulations either for the materials or systems should present their behavior as a temperature–time function rather than as fitting into a particular temperature or material class.

Digest of paper **54-121**, "The Functional Evaluation of Insulation for Small Dry-Type Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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# All-Electronic 1-Cycle Carrier Relaying

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**This carrier-relaying system meets the requirements for ultrahigh-speed operation. A relaying time of 1/2 cycle to a maximum of 15/16 cycle has been obtained and both ease of maintenance and reliability have been achieved. This system has broad applications and its accuracy and sensitivity are equal to or exceed its electromechanical counterpart.**

An all-electronic directional comparison carrier-relaying system having a maximum over-all operating time of less than 1 cycle has been tested successfully both in the laboratory and by staged tests in the field. In order to obtain operating experience, this equipment, see Fig. 1, is in temporary service on the Appalachian Electric Power Company's 43-mile 132-kv transmission line between Roanoke and Lynchburg, Va. Permanent installation is planned on the 330-kv system of the American Gas and Electric Company. This equipment is the result of several years' intensive study and tests to determine the best system of transmission-line relaying capable of operating under all conditions in less than 1 cycle after the inception of a fault.

## BASIC SCHEME

The expansion in system capacity and the trend to higher line loadings makes it necessary to provide protective relaying equipment which will reduce materially the fringe times of 3 to 4 cycles sometimes encountered with carrier relaying presently available. The decision to develop an electronic system for line protection was made only after sufficient study and experience provided assurance that the degree of reliability required for such applications could be obtained, and that the problems involved in developing an electromechanical system of such fast operating time would be very difficult to solve.[1] The system was designed to meet the following general requirements:

1. Provide a maximum relaying time of 1 cycle for any practical value of fault current.
2. Have broad application for transmission-line protection.
3. Maintain accuracy and speed of performance throughout tube life.
4. Have maximum electronic reliability.
5. Provide "first line" protection only, with backup protection provided by electromechanical devices.

Conventional directional comparison carrier relaying was chosen for this system because it has a broader range of application than a phase comparison or a transfer trip scheme.[2]

The all-electronic 1-cycle carrier relaying system has as its main functions phase and ground tripping, carrier starting, and out-of-step blocking. Also used are a carrier control unit, a conventional carrier transmitter-receiver, and a thyratron tripping relay.

## GROUND RELAYING

The ground overcurrent relay, see Fig. 2, is energized by the residual current, $I_R$, of the line current transformers. During a ground fault, this current actuates the overcurrent fault-detecting units. The starting unit output is applied to the carrier control unit where the signal is amplified and then supplied to the carrier transmitter to send carrier. The tripping unit output is connected as plate supply for the final stage of the ground directional relay. An intentional time delay of 4/10 cycle is inserted in this signal for two purposes:

1. To allow time for the remote terminal to set up blocking.
2. To allow time for the directional relay to reset in the event that it was actuated due to load unbalance prior to the fault.

The ground directional relay receives the usual two a-c quantities. The polarizing quantity is the neutral current,

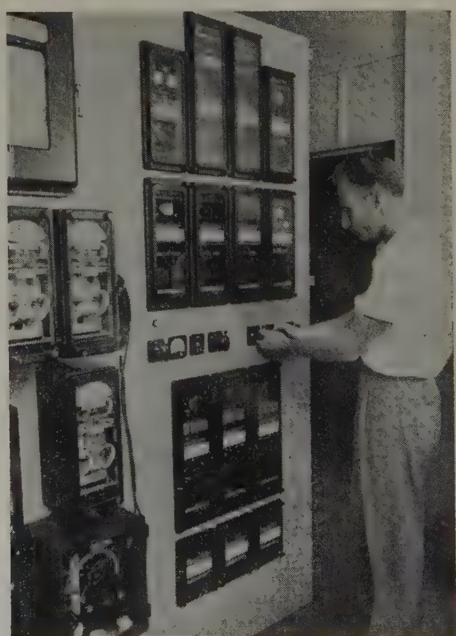

**Fig. 1. All-electronic 1-cycle carrier-relaying terminal of the Appalachian Electric Power Company's Lynchburg installation**

Summary of papers **54-111, 54-147, 54-148,** and **54-149** (see references for titles) recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and published in AIEE *Power Apparatus and Systems,* 1954.

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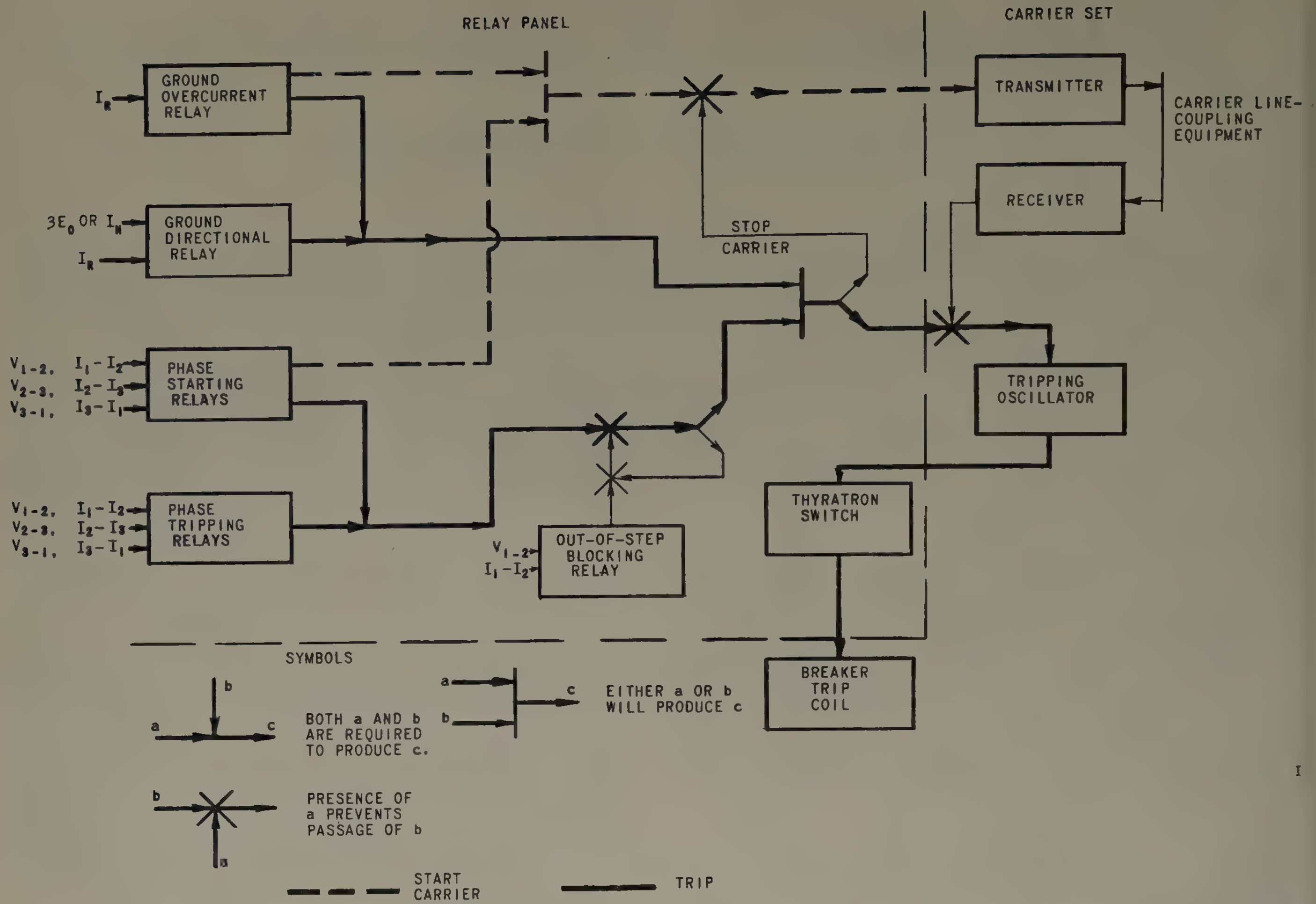


**Fig. 2. All-electronic 1-cycle carrier-relaying block diagram**

$I_N$, from a transformer bank, or the zero sequence voltage, $3E_O$, from a broken delta transformer. The operating quantity is the residual current derived from the line-current transformer $I_R$, which also is supplied to the overcurrent relay.

When ground fault current flows from the line to the bus, the directional relay does not operate, and carrier is transmitted continuously by the overcurrent starting unit to block tripping at the opposite terminal of the transmission line. When fault current flows from the bus into the line, the directional relay operates, and after the co-ordination delay of the overcurrent tripping unit has elapsed, a tripping output is produced. This output is applied to the carrier control relay which then stops the sending of carrier and supplies an amplified signal to the tripping oscillator.

The tripping oscillator unit is the heart of the electronic directional comparison carrier-relaying system. It corresponds to the receiver relay in the electromechanical system. It is the function of this unit to produce a trip voltage when there is a signal from the carrier control relay, and there is no blocking by received carrier. This condition indicates a fault is internal to the protected line section. When carrier is received, the indication is that the fault is external to the remote terminal. With no received carrier, and with a trip signal from the carrier control relay present, the oscillator operates and transmits a tripping signal to the thyratron switch which in turn energizes the breaker trip coil.

## PHASE RELAYING

The phase 1–2 carrier-starting relay, see Fig. 2, is energized from the line currents, $I_1$ and $I_2$, and the phase voltage $V_{1-2}$. Phase 2–3 and 3–1 relays receive corresponding currents and voltages. The double modified impedance characteristic, shown in Fig. 3, is the locus of the reach of the starting relay. One output from this relay is used in the same manner as the output of the ground overcurrent relay to start carrier. A separate co-ordination signal output controls the phase-tripping relay in the same way in which the ground overcurrent tripping unit signal controls the ground directional relay. This trip co-ordination signal is delayed to allow time for the starting relay at the remote terminal to set up carrier blocking. Signals from the three carrier-starting phase relays are combined to produce one signal for carrier starting, and one co-ordination signal to control all three tripping relays.

The phase-tripping relays have the same inputs as the phase-starting relays. The mho characteristic shown in the *RX* diagram of Fig. 3 is the locus of the reach of each phase relay. A fault which lies within the mho circle causes a tripping signal to be transmitted to the carrier control relay if a co-ordination signal is present from the

phase-starting relays. The sending of carrier is stopped and a signal is applied to the tripping oscillator in the same manner as in ground relay operation. The action of the oscillator is the same regardless of the type of fault.

## LEVEL DETECTOR

Throughout this equipment there is a recurring need for an electronic measuring device which can respond to a specific signal voltage level and exert control over succeeding functions in a minimum amount of time. An electronic "switch," termed a "level detector,"[3] has been developed to meet the requirements of stabilized response to a given instantaneous positive signal magnitude regardless of waveform. Delay time between an input signal of pickup amplitude and the output signal is extremely short in accordance with the objective of the over-all system. Because of the versatility of the unit which was developed, this basic circuit is repeated at 21 points in each terminal. Standardization of building blocks has been accomplished in many instances in this system.

## SPECIAL CONSIDERATIONS

In ultrahigh-speed relaying, effects that seldom or never had to be considered with conventional electromechanical relaying must be taken into account. Unequal breaker pole closures, component reliability, and d-c supply voltage variations are typical examples.

If, during circuit breaker closing on an energized line, one pole makes contact before the other two, zero sequence currents will flow. This condition will appear to the ground directional relay as an internal phase-to-ground fault, and with relaying of sufficient sensitivity and speed, such as in this scheme, an immediate retrip may occur. Only in isolated instances has this been a problem with conventional electromechanical relaying. To alleviate this condition and still not delay relaying any longer than necessary, the co-ordinating signal from the overcurrent tripping unit to the ground directional relay is blocked by circuit breaker auxiliary switches until the last pole is closed.

To achieve high reliability, long-life industrial-type tubes are used. Heater current regulation is used to extend vacuum tube life. In general no component is operated at more than 50 per cent of its rating, and even under peak intermittent operating conditions the nominal rating of a component seldom is reached.

By proper choice of circuitry and circuit parameters, relaying accuracy and the maximum relaying time of 1 cycle never is exceeded for battery supply variations over which existing carrier equipments now operate.

A close check on the operating characteristics of the initial installation was desirable. To do this and reduce maintenance time, a test fault scheme has been included on each panel. It enables the station operator to remove all relays from service with a single switch, and to apply preset voltages and currents to the individual relays which simulate internal or external faults. This test method also is used to check conventional electromechanical distance relays. Normally, portable test equipment is used for this purpose. A hand reset auxiliary relay on the panel installation is tripped by the electronic relays and provides a simulated circuit breaker operation. The conventional carrier test scheme also is included in the installation for checking carrier transmission.

## LABORATORY AND FIELD TESTS

Although extensive tests checked the performance of each relay on an individual basis, they gave no conclusive answer concerning over-all performance of the relays when connected to operate as a complete directional comparison carrier-relaying system. To determine the over-all performance of the system, comprehensive laboratory and staged fault tests were conducted.

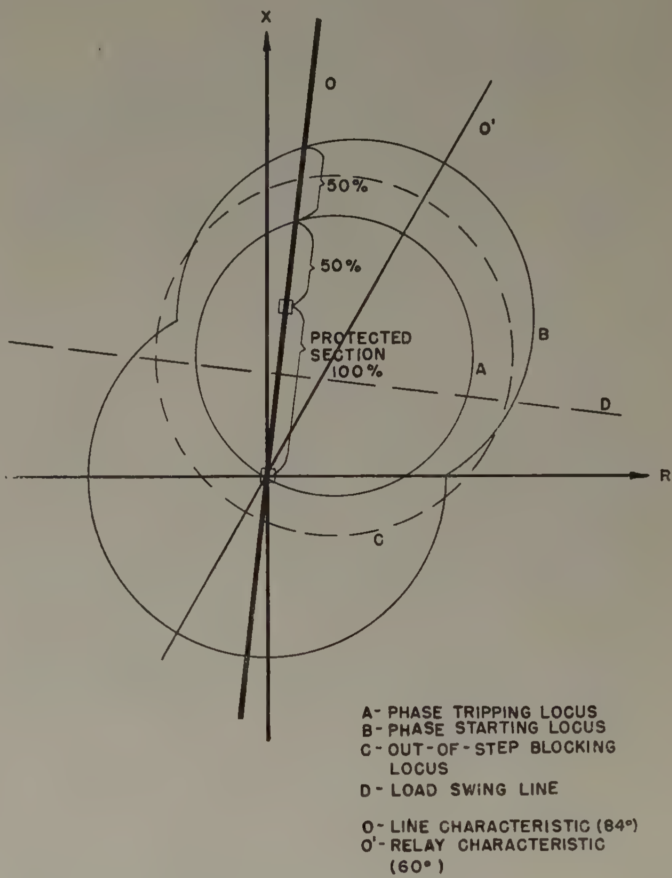


**Fig. 3. Impedance characteristics of the phase relays**

In the laboratory at the factory two terminals of the electronic relays, each equipped with a carrier-current transmitter-receiver, were connected to an artificial transmission line. Oscillograph records were taken at each end of the artificial line to record line current, line voltage, trip current, carrier drive signal, trip drive signal, and carrier signal alarm tube current. Faults were applied by means of a synchronous switch in order to control the point of fault inception in the line-voltage cycle. Both internal and external "arcing" and metallic faults were applied at each end of the line. Arcing faults were simulated by using nonlinear resistance in the fault circuit.

The artificial line configurations were selected from the

American Gas and Electric Company's 330-kv system, and were those which would impose the most adverse operating conditions upon the relay equipment from the viewpoint of fault quantities seen by the relays.[4] Throughout the laboratory tests the relays performed correctly.

Although the laboratory tests were comprehensive, it was impossible to simulate all conditions under which these relays would be required to operate in service. Accordingly, an extensive field test program was arranged comprising both staged fault tests and field experience. Among other things, the staged fault tests demonstrated the effect of system and potential device transients on the relay equipment during actual faults, and proved that the various co-ordination times in the relays were satisfactory. In addition, the service experience now being obtained will yield information on the reliability of the tubes and other components of the relaying system.

Staged fault tests were conducted on August 8 to 10, 1953, consisting of 18 short circuits of various types applied to the Roanoke-Lynchburg line of the Appalachian Electric Power Company. Several problems were brought out by these tests and the subsequent 4 months of operating experience. Only one of these problems was unique to electronic relaying. It was found that random surges from the station control circuits occasionally caused incorrect operation at the Roanoke terminal. Filtering and shielding of critical circuits at both terminals corrected this problem.

A second series of staged fault tests was conducted on December 5 and 6, 1953. Specific tests were selected to determine whether the changes that had been incorporated in the relays since the August 8 to 10 staged fault tests were satisfactory, and to ascertain what type of operation might be expected if the electronic relays were supplied by potential devices. Nineteen faults were applied to the Roanoke-Lynchburg line, and the relays operated completely satisfactorily in all instances. The difficulties that were encountered during the initial service period and in the first series of staged fault tests all were shown to have been corrected. Since these tests, the relays have been in continuous service, and have performed satisfactorily.

## BACKUP PROTECTION

A COMPLETE relay protective system must provide backup protection in addition to the "first line" high-speed operation for internal faults. Since backup operation is inherently slow acting, this function can be provided by presently available electromechanical relays. In fact, there is no justification for the use of the more complex and more costly electronic techniques for backup functions.

## SUMMATION

THIS all-electronic 1-cycle carrier-relaying system meets the requirements for ultrahigh-speed operation. Relaying time of 1/2 cycle to a maximum of 15/16 cycle has been obtained. Ease of maintenance and reliability have been incorporated to a high degree. This system has broad application, and its accuracy and sensitivity are of the same order as or greater than the electromechanical counterpart. The laboratory and field tests indicate that this electronic carrier-relaying equipment operates satisfactorily under normal and adverse service conditions. High speed necessarily involves increased complexity to perform functions that are relatively simple in electromechanical relays. As in the case of circuit breakers, the higher cost of the faster equipment is justified by economies which are made possible in the transmission system.

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# Radiation Source for Food Sterilization Studies

A new type of experimental radiation source which utilizes radioactive waste products has been developed at Argonne National Laboratory for use in food sterilization studies.

The source is a small hollow cylindrical block of concrete which was prepared by mixing cement and liquid radioactive fission products. The latter are the by-products created when neutrons bombard uranium 235 in a nuclear reactor. The highly radioactive cement-fission product mixture is surrounded on all sides, top, and bottom by several inches of ordinary concrete and a lead shield which is also several inches thick. This shield is necessary in order that experimenters using the source will not be exposed to the harmful radiation. The opening into the center of the source is provided so that materials to be irradiated may be lowered into the active region of the source. This type of source possesses the following advantages: (1) the radioactivity used is obtained as a by-product of reactor operations and as such is inexpensive; (2) it provides, in addition, an ideal method of disposing of the highly radioactive waste products which present serious storage or disposal problems; and (3) it provides for experimental use a radiation source of the type and energy which will be used if large-scale food sterilization by irradiation proves to be feasible.

The Argonne-developed source, equivalent in radiation intensity to several pounds of radium, has been shipped to the Department of Food Technology, Massachusetts Institute of Technology, where it will be used in important studies dealing with the effects of radiation on micro-organisms in food. This is regarded as a significant step forward in developing peacetime uses of atomic energy.

# Induction Motor Theory—Suprasynchronous Speeds

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MEMBER AIEE

THERE ARE TWO FACTS about single-phase induction motors which have not been generally recognized.

1. The magnitude of the flux in the quadrature axis at the instant the main flux is zero diminishes as the speed is increased above synchronism.

2. The rotor current resulting from the rotor voltage due to the backward rotating flux component provides the mmf for the positive flux in the quadrature axis.

There has been ample demonstration that the actual current in any one rotor bar of a single-phase induction motor while running normally consists of two components, one having slip frequency and the other having twice line frequency minus slip. Each of these components is comparable with the current resulting from a constant rotating field; i. e., at any instant the current magnitude from bar to bar around the rotor is sinusoidally distributed, and there is always at every instant one bar (lagging behind the corresponding flux vector) which is carrying maximum current. The angle of lag is, of course, different and in opposite direction below synchronous speed for the two flux vectors and corresponding current components.

Fig. 1 is a schematic of the single-phase rotor, with forward and backward flux components, at the instant when primary flux is zero. $I_{2FD}$ represents that component of current due to rotor voltage produced by the forward rotating flux $\phi_F$ which is in phase with $\phi_F$. The other three rotor current components are correspondingly represented.

A little study by the thumb-and-fingers method will show that whereas $I_{2FD}$ and $I_{2BD}$ tend to produce flux in the same direction through the rotor (but do not produce any because of the primary winding in that axis), $I_{2FQ}$ and $I_{2BQ}$ are in opposite directions. If they were equal in magnitude, $\phi_B$ would be equal to $\phi_F$ and there would be no net flux (as at standstill) in the quadrature axis. It also is seen that $I_{2BQ}$ is in a direction to re-enforce $\phi_F$, and $I_{2FQ}$ is in a direction to produce $\phi_B$. This does not mean that $\phi_F$ is necessarily proportional to $I_{2BQ}$ and $\phi_B$ is proportional to $I_{2FQ}$; but it does mean that $\phi_F-\phi_B$ is proportional to $I_{2BQ}-I_{2FQ}$.

It is interesting to note what happens above synchronous speed. In that case, both $\phi_F$ and $\phi_B$ may be said to rotate backward with respect to the rotor. That means, of course, torque input at the shaft. It does not mean, however, that the direction of the mmf due to $I_{2FQ}$ reverses and adds instead of subtracting from the mmf in the $X$-axis due to $I_{2BQ}$. If it did, the quadrature flux would become larger than at synchronism. The situation still exists that $\phi_F$ never can be as large as the primary flux under any conditions. If it were, there would be no $\phi_B$ since $\phi_B=\phi_M-\phi_F$. If there were no $\phi_B$, there would be no mmf to produce $\phi_F$.

When the left rotation arrow in Fig. 1 reverses direction

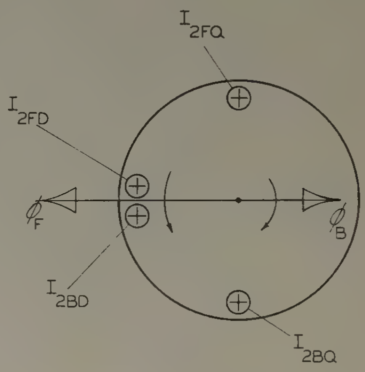


**Fig. 1. Flux and rotor current components of single-phase motor, when main flux is zero. Rotation arrows indicate direction of flux rotation with respect to rotor**

at transition to speeds above synchronism, obviously the direction of $I_{2FD}$ reverses—causing reversal of that component of primary current as stated. It is true also that since $I_{2F}$ reverses sign, $I_{2FQ}$ reverses; but the conductor in which $I_{2FQ}$ is maximum must be 90° behind the flux vector. $I_{2FQ}$ negative is then 180° from the position of $I_{2FQ}$ shown in Fig. 1—in the same position as the negative bar not shown was at normal motor speed.

Flux in the quadrature axis but in phase with the main flux may be expected to result from $I_{2BD}-I_{2FD}$ or $I_{2FD}-I_{2BD}$. The effect of this is to shift the resultant flux from the main or primary axis to a slight angle backward. $I_{2FD}$ will be larger than $I_{2BD}$ because $I_{2F}$ is greater than $I_{2B}$, and also $\theta_F$ is a smaller angle than $\theta_B$. A practical rationalization of the backward inclination of total flux when primary flux is maximum is that the rotor is carrying flux around with it; and the primary pulls the flux into line but there is always a "foot-dragging" process.

The total flux locus with respect to the stator has been said in many texts to be an ellipse with main axis coinciding with the primary axis. Some texts indicate that the larger axis of the ellipse is in the quadrature position above synchronism. It is seen from the foregoing that the main axis of the ellipse inclines backward below synchronism, and inclines slightly forward above synchronous speed. The fact that $\phi_F$ and $\phi_B$ do not come together exactly at the primary axis results in the possibility under some conditions for the maximum total density at one point in the gap to exceed that under the middle of the main pole—but at 90° from that position the density never can be larger than maximum primary gap density, at any speed whatsoever.

Digest of paper 54-20, "Induction Motor Theory—Some Elementary Concepts Extending to Suprasynchronous Speeds," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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# Parallel Windings in Multiwinding Transformers

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MEMBER AIEE

THE GROWTH in size and complexity of power systems has resulted in a trend toward multiwinding transformers. A frequent consideration in the application of these multiwinding transformers is the possibility of paralleling secondary windings.

When considering the paralleling of windings it is important to distinguish between true paralleling and pseudo paralleling. True paralleling exists when proper load division between two or more windings having the same voltage is determined by the transformer winding impedances. Pseudo paralleling exists when proper load division between two or more windings having the same voltage is determined by factors independent of winding impedances. Cases of true paralleling include windings bussed close to the transformer terminals with negligible impedance between the windings and bus, and series-parallel winding arrangements for obtaining fractional voltages. Cases of pseudo paralleling include windings fed by independent generators and windings feeding separate transmission lines bussed at long distances from the transformer.

In the design of transformers for either true or pseudo paralleling, winding arrangements are chosen to obtain minimum unbalance and stray losses under the required conditions of loading. In the case of true paralleling, additional relations between the two winding impedances must be met to insure equal load division.

The most common case of paralleled secondaries is the 3-winding transformer with two paralleled secondaries. The necessary impedance relation for true paralleling in this case is that the impedance from the supply winding to each secondary be equal. Unfortunately, this condition cannot be applied as a general paralleling criterion for multiwinding transformers with more than three windings. The necessary criteria are more complex and also involve the impedances between pairs of secondaries.

By employing equivalent circuits and the fundamental transformer equations it is possible to establish the necessary impedance relations or criteria for the paralleling of the remaining secondaries of a multiwinding transformer when fed by a single supply winding. The relations are reciprocal in nature and apply as well to a multiplicity of supply windings feeding a single loaded secondary. These relations are tabulated as follows for the 3-, 4-, 5-, and *n*-winding transformer. In each case the supply winding is designated as winding *1*, and the secondaries numbered *2* and above are assumed to have equal voltage and kva rating.

Digest of paper 54-46, "Parallel Windings in Multiwinding Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, February 1954, pp. 27–31.

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## CRITERIA FOR PROPER PARALLELING OF SECONDARIES

3-Winding $[Z_{13}-Z_{12}]=0$

4-Winding
$$3[Z_{13}-Z_{12}]=Z_{34}-Z_{24}$$
$$3[Z_{14}-Z_{13}]=Z_{42}-Z_{32}$$

5-Winding
$$4[Z_{13}-Z_{12}]=Z_{34}-Z_{24}+Z_{35}-Z_{25}$$
$$4[Z_{14}-Z_{13}]=Z_{42}-Z_{32}+Z_{45}-Z_{35}$$
$$4[Z_{15}-Z_{14}]=Z_{52}-Z_{42}+Z_{53}-Z_{43}$$

$$(n-1)\ [Z_{13}-Z_{12}]=\sum_{m=2}^{m=n}[Z_{3m}-Z_{2m}]$$

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*n*-Winding $2<p<(n-1)$
$$(n-1)\,[Z_{1(p+1)}-Z_{1p}]=_p\sum_{m=2}^{m=p-1}[Z_{(p+1)m}-Z_{pm}]+\sum_{m=p+2}^{m=n}[Z_{(p+1)m}-Z_{pm}]$$

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$$(n-1)[Z_{1n}-Z_{1(n-1)}]=\sum_{m=2}^{m=n-2}[Z_{nm}-Z_{(n-1)m}]$$

The double subscript impedances are the 2-winding short-circuit impedances of the transformer.

Examination of these relations reveals that equality of impedances from supply winding to each secondary is not sufficient to permit proper paralleling above a 3-winding transformer. Equality of impedances between supply and secondaries reduces the left-hand side of these criteria to zero. If, in addition, the impedances between pairs of secondary windings are equal the right-hand side also reduces to zero thus satisfying the criteria. Therefore, equal impedances between supply and secondaries and equal impedances between pairs of secondaries will permit proper paralleling. These conditions represent the relationships present in the symmetrical split-winding transformer. This winding arrangement has the property that any combination of secondary windings can be paralleled with the remainder left idle without upsetting the load division between the loaded windings. On the other hand, it has the disadvantage that it requires increasingly complex winding arrangements for transformers with more than three windings.

However, in addition to the symmetrical split winding there are many other winding arrangements capable of satisfying the paralleling criteria. These represent the more general solutions in which both sides of the relations have finite but equal values. They can be used in cases where all secondaries are loaded simultaneously. Their advantage lies in the relatively simple winding arrangements required.

Although the general paralleling criteria were derived for the case where all secondaries are simultaneously loaded, they also can be used to determine whether a specific combination of secondaries can be paralleled when one or more of the secondaries is open and idle.

# INSTITUTE ACTIVITIES

## Summer and Pacific Meeting to Feature 53 Sessions, Timely Inspection Trips

It has been announced that 53 sessions will comprise the technical program of the AIEE Summer and Pacific General Meeting to be held at the Hotel Biltmore, Los Angeles, Calif., June 21–25, 1954. These, together with the annual business meeting on Monday morning and the timely inspection trips, should make this meeting one of outstanding technical importance.

Among the technical papers which should prove of great interest are the following: The Committee on Special Communications Applications will sponsor a paper on wartime telecommunications experiences in a European country by an engineer who formerly was in charge of Hungarian telecommunications, a presentation covering the present status of magnetic-tape data recording systems, and a paper covering the terminal handling of telegrams in Los Angeles. A session on light traction, planned by the Committee on Land Transportation, will present discussions of an electric system for Monorail rapid transit, high-speed rapid transit equipment, the rebuilding of San Francisco's transit system, and the Swiss Gyrobus, a flywheel trolley coach that has been developed in Switzerland. The system aspects of extra-high-voltage transmission will be the subject of several papers scheduled by the Subcommittee on System Planning.

The present schedule of technical sessions is as follows:

**Monday, June 21**

**2:00 p.m.**

Television and Aural Broadcasting Systems
Land Transportation
Chemical, Electrochemical, and Electrothermal Applications
Medical Radiation Instruments
Transmission and Distribution and Protective Devices
Magnetic Amplifiers

**Tuesday, June 22**

**9:00 a.m.**

Radio Communications
Mining and Metal Industries
Nuclear Reactors
Transmission and Distribution
Magnetic Amplifiers
Management

**2:00 pm.**

Radio Communications
Nuclear Measurements
Transmission and Distribution
Magnetic Amplifiers
Relays
Feedback Control Systems

**Wednesday, June 23**

**9:00 a.m.**

Wire Communications
Feedback Control Systems
Instruments and Measurements
Steam Power Stations
Insulated Conductors
Basic Sciences
Semiconductors

**2:00 p.m.**

Wire Communications
Feedback Control Systems
Rotating Machinery
Insulated Conductors
Industrial Power Systems
Instruments and Measurements
Semiconductors

**Thursday, June 24**

**9:00 a.m.**

Communication Switching Systems
Instruments and Measurements
Hydroelectric Power Stations
Transformers
Domestic and Commercial Applications
Safety

**2:00 p.m.**

Computing Devices
Carrier Current
Rotating Machinery
Transformers
Electronics
Domestic and Commercial Applications

**Friday, June 25**

**9:00 a.m.**

Computing Devices

**The Wilshire Country Club in Los Angeles where golfers will compete on Tuesday, June 22, for various prizes including the J. B. Fisken cup, and the ladies will lunch following their Wednesday tour**

### Future AIEE Meetings

**AIEE-IRE-RETMA-WCEMA Electronic Components Conference**
Roger Smith Hotel, Washington, D. C.
May 4–6, 1954
(*Final date for submitting papers—closed*)

**North Eastern District Meeting**
Van Curler Hotel, Schenectady, N. Y.
May 5–7, 1954
(*Final date for submitting papers—closed*)

**Appliance Technical Conference**
Morrison Hotel, Chicago, Ill.
May 17–19, 1954
(*Final date for submitting papers—closed*)

**Electric Welding Conference**
Schroeder Hotel, Milwaukee, Wis.
May 19–21, 1954
(*Final date for submitting papers—closed*)

**AIEE-IAS-IRE-ISA Conference on Telemetering**
Morrison Hotel, Chicago, Ill.
May 24–26, 1954
(*Final date for submitting papers—closed*)

**Summer and Pacific General Meeting**
Biltmore Hotel, Los Angeles, Calif.
June 21–25, 1954
(*Final date for submitting papers—closed*)

**Petroleum Technical Conference**
Tulsa, Okla.
September 27–29, 1954
(*Final date for submitting papers—June 28*)

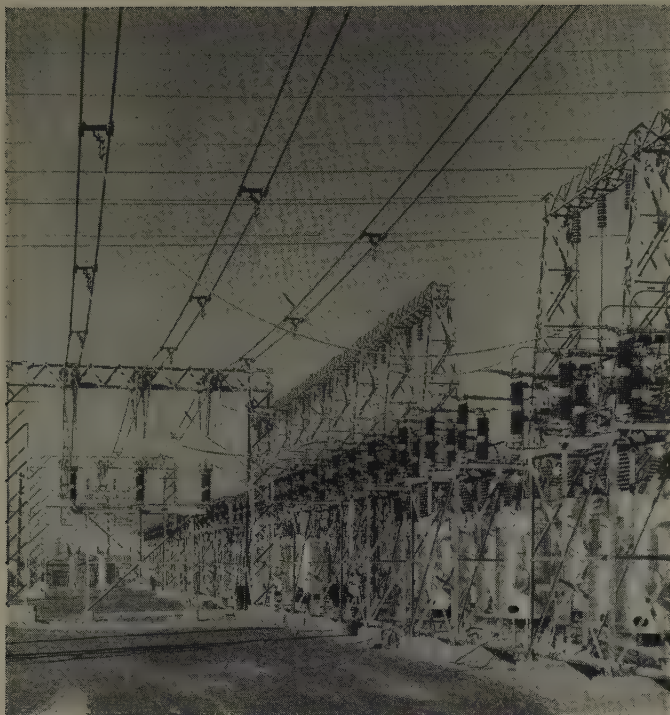
**Middle Eastern District Meeting**
Abraham Lincoln Hotel, Reading, Pa.
October 5–7, 1954
(*Final date for submitting papers—July 7*)

**Fall General Meeting**
Morrison Hotel, Chicago, Ill.
October 11–15, 1954
(*Final date for submitting papers—June 14*)

**Machine Tool Conference**
Hotel Statler, Detroit, Mich.
October 25–27, 1954
(*Final date for submitting papers—June 25*)

**Southern Textile Conference**
Raleigh, N. C.
November 4–5, 1954
(*Final date for submitting papers—August 4*)

**1955 Winter General Meeting**
Hotel Statler, New York, N. Y.
January 31–February 4, 1955
(*Final date for submitting papers—October 20*)



**An inspection trip is scheduled to the Laguna Bell Substation of the Southern California Edison Company, first 220-kv station in the country. Shown here is a section of 66-kv double-suspension-type bus recently installed to replace the early rigid-type bus**

System Engineering
Switchgear
Electronics
Air Transportation
General Industry Applications

**2:00 p.m.**

Computing Devices
System Engineering
Switchgear
Electronics
Air Transportation
Special Communications

LUNCHEON PROGRAMS

Luncheon programs have been scheduled at the Biltmore for the first 3 days of the meeting. Outstanding leaders in the fields of industry, education, and national resources will be featured guests.

On Monday, June 21, a prominent speaker will talk regarding phases of our national resources that are associated with the fields of engineering.

Walker L. Cisler, president of the Detroit Edison Company, will speak following the luncheon on Tuesday regarding the present status of atomic energy generation.

Dr. Lee A. DuBridge, president of the California Institute of Technology, will speak at the luncheon on Wednesday on the responsibilities of the universities in the field of education, the conduct of pure and applied research, and the provision of technical services for public agencies and for the public welfare.

INSPECTION TRIPS

The inspection trips will complement the technical sessions and accordingly have been scheduled to avoid conflict of common interests.

*Kaiser Steel Company, Fontana; Exchange Orange Products Company, Ontario* (Round trip 100 miles, Monday, June 21, 1:00 to 5:00 p.m., $2.50). The Kaiser plant is able to show practically all phases of steel making from ore and coal to finished sheets and shapes, including coke making, blast and open hearth furnaces, and rolling mills.

The Orange Products plant will show the processing of oranges into frozen concentrated juice, orange oil, molasses, pulp, pectin, and essential oils.

*Columbia Broadcasting System and National Broadcasting Company Television Production Studios; Pacific Telephone Television Transmission Facilities, Hollywood* (All of these facilities will be seen in operation on Monday evening from 7:00 to 10:00 p.m., $1.00). Both broadcasters have constructed huge studio facilities where programs for national network and local release are produced. These programs are transmitted from the studios to nation-wide transmission circuits and to broadcasting stations on Mount Wilson via Pacific Telephone's Hollywood office.

*North American Aviation Company, Inglewood* (Tuesday, 9:00 to 11:45 a.m., $1.00). At North American the supersonic speed *Sabre* jets are manufactured. Other facilities which will be seen are the supersonic wind tunnel, test chamber which duplicates pressures and temperatures experienced up to 85,000 feet altitude, and extensive other facilities for engineering and testing all phases of airplane research and production.

*Richfield Refinery and Oil Fields* (Tuesday, 2:00 to 5:00 p.m., $1.00). This 560-acre plant near Wilmington, processing 115,000 barrels of oil a day into 50,000 barrels of gasoline plus other products, exemplifies the transition of electric distribution, control, and switching facilities as the refinery grew from a small into a large modern plant.

*Mount Wilson Observatory and Television Stations* (Tuesday, 4:00 to 10:00 p.m., $3.50 including box supper). This is planned as a late afternoon and early evening trip in order that the scenery and the cities may be viewed under varying conditions and a stop for supper will be made en route. The 20-mile trip up the mountain is on a thoroughly safe, high-gear road. If visibility is good, from the top one can see for 150 miles. Visitors will inspect the Observatory, the television stations, and Pacific Telephone's facilities for serving the broadcasters.

*Laguna Bell Substation, Southern California Edison Company, Bell* (Wednesday, 9:00 to 11:45 a.m., $1.00). This is the oldest 220-kv substation in the country. Of particular interest is the modern, earthquake-resistant, flexible bus design.

*Lockheed Aircraft Corporation, Burbank* (Wednesday, 9:00 to 11:45 a.m., $1.00). This trip is concerned with the computer facilities used in solving the mathematical problems posed in the design of modern aircraft. The facilities include a general-purpose analogue computer, both amplifier and digital differential analyzers, and an International Business Machines Sequence Computer. Due to restricted space, attendance must be limited to 40 United States citizens.

*Hoffman Radio Corporation* (Wednesday, 2:00 to 5:00 p.m., $1.00). Production-line manufacture and testing of commercial television sets will be viewed in this modern plant which uses more than a mile of overhead conveyers to carry picture tubes, chassis assemblies, and cartons to the final assembly line.

*Lever Brothers* (Wednesday, 9:00 to 11:45 a.m., $1.00). This trip will be of interest to both the members and the ladies. The production of cosmetics and soaps in this very modern, attractive plant has both popular and technical appeal.

*Valley Steam Plant and Receiving Station G, Los Angeles Department of Water and Power* (Wednesday, 2:00 to 5:00 p.m., $1.00). This is an opportunity to see an ultramodern steam plant in all stages of construction and operation. Unit 1 will be in operation, Unit 2 will be in process of assembly, and Units 3 and 4 will be under construction. En route a stop will be made at Receiving Station *G* which is one of ten similar stations which receive bulk power at transmission voltage from generating sources and distribute it at 34.5 kv to substations and industrial customers.

*Etiwanda (Southern California Edison Company) Steam Plant; Highgrove (California Electric Power Company) Steam Plant; Riverside Mission Inn* (Thursday, 9:00 a.m. to 5:00 p.m., $5.00 including luncheon). In this 125-mile round trip it will be possible to inspect not only these two very modern outdoor-type steam-electric generating plants, but also to have lunch at the historic Riverside Mission Inn.

*Los Angeles Toll Office, Television, Radio, and Coaxial Cable Facilities; No. 4A Crossbar Switching Machine.* Beginning Monday afternoon through Thursday, at 9:30 a.m. and 1:30 p.m. for television facilities and 10:30 a.m. and 3:30 p.m. for the Crossbar machine, Pacific Telephone will demonstrate and explain the intricacies of these installations. The office is only a block from meeting headquarters.

*California Institute of Technology, Pasadena* (Friday, 9:00 to 11:45 a.m., $1.00). This concluding scheduled inspection trip covers a wide field of interest:

1. The high-voltage laboratory which was the first to produce 1,000,000 volts at power frequencies.

2. The Synchrotron, which produces 1,000,000,000 electron volts and is used in nuclear investigations.

3. Analysis laboratory which has the analogue computer used by the aircraft industry in aircraft design.

4. Hydrodynamic laboratory in which, with models, the design of craft for surface and shallow submergence operation is studied.

5. Guggenheim laboratory in which wind velocities up to 11 times the speed of sound may be created.

### LADIES' PROGRAM

A committee of 100 ladies, with Mrs. Ernest K. Sadler as chairman and Mrs. Bradley Cozzens as vice-chairman, has arranged a program for the ladies which should make their visit to Los Angeles a most enjoyable one.

The Galleria Room of the Biltmore Hotel has been reserved for the exclusive use of the ladies from Monday through Thursday. A coffee hour will be held there each morning at 9:00 a.m. All the ladies cordially are invited to attend.

A fashion tea has been planned for Monday at Bullock's Wilshire store at 3:00 p.m. Busses will leave the Biltmore Hotel from 1:30 to 2:30 p.m. and leave the store at 5:00 p.m. for the return trip, allowing adequate time for shopping in this very beautiful and exclusive shopping district. Tickets will be $1.00.

On Tuesday there will be a tour through the orange grove country, to Padua Hills Restaurant, situated on an olive-clad hill at the base of the Sierra Madre Mountains. Here the romance and beauty of early California and the charm of Mexico will be brought alive by Mexican players, who will entertain with Spanish songs and dances during the luncheon hour. Busses will leave the Biltmore Hotel at 10:30 and 11:30 a.m. The attendance at this event is limited to 200, so reservations should be made early. Tickets will be $3.75.

On Wednesday morning there will be a trip to Forest Lawn Memorial Park to view the famous "Last Supper" window and the painting of the "Crucifixion" by Jan Styka. Busses will leave the hotel at 9:15 a.m. and return at 12:00 noon. At 1:30 p.m. busses will leave the hotel for a tour of the Huntington Library and Art Gallery, which houses many treasures of art and literature, including the original "Blue Boy" by Gainsborough. Tickets will be $1.00 for each trip.

Busses will leave the Biltmore at 10:00 a.m. on Thursday for a tour of Beverly Hills, movie stars' homes, the University of California at Los Angeles, and to the Pacific Ocean beach towns, arriving at 1:00 p.m. at the beautiful Wilshire Country Club for luncheon, followed by entertainment by Miss Lynn Blakeslee, concert violinist. The Luncheon Committee has arranged to have many door prizes at this event. Tickets are $4.50.

### SPORTS

Golf has been arranged for the registered AIEE members and their guests. On Tuesday, June 22, golf players will tee off starting at 11:00 a.m. at the Wilshire Country Club. Golfers should register at the Sports Information Desk for starting time and transportation, if desired. All registered members and guests are invited to participate in the golf tournament. Registered male members of Districts 8 and 9 (Pacific Coast members) are eligible to compete for the J. B. Fisken cup, a perpetual trophy. The Fisken cup is awarded for low net score—18 holes Medal play. Player's handicaps are to be registered with the Golf Committee based on his club handicap and course par, or an average of his last three scores on his regular course. Independent of the award of the John B. Fisken cup will be prizes for low gross, low net, and blind bogey scores, open to all players. Any golfers desiring noncompetitive golf on days other than June 22 should consult with the Sports Desk for arrangements. Full use of all club facilities by the players has been arranged. Locker space and rental clubs for members will be available. The green fee is $5.00 per player; the caddy fee, $4.00 per player. Caddy carts are not in use at Wilshire Country Club.

Tennis, swimming, and horseback riding will be available also. If advance notice indicates that sufficient players are interested, a tennis tournament can be arranged to be played on June 22. If enough interest is indicated in deep sea fishing, a party will be scheduled.

### OTHER ACTIVITIES

A family-style dinner will be held at Knott's Berry Farm, Buena Park, on Wednesday, 4:30 to 10:30 p.m. The farm is famous initially as the home of the "boysenberry," and secondly for its authentic "Ghost Town" where relics of the Gold Rush days have been transplanted to provide several hours of amusement with historic interest. Cost will be $5.00, including chicken dinner.

The highlight of the Summer and Pacific General Meeting will be the President's Reception and Banquet to be held in the Biltmore Bowl on Thursday evening. Drawing upon the entertainment facilities of the motion picture center, the Entertainment Committee promises a very pleasant evening for everyone.

Previous items have stressed the planning of a trip to the meeting so that the utmost satisfaction may be gained en route as well as in the Los Angeles area. The Transportation Committee will answer all inquiries. They should be addressed to Robert A. Young, Chairman, 3905$^1/_2$ San Fernando Road, Glendale 4, Calif. For the vacationer, either before or after the meeting, there are facilities available nearby for any type of outdoor recreation, and it is suggested that members take advantage of the opportunity to vacation in Southern California.

## AIEE Appliance Conference to Cover Testing and Control

"Performance Testing and Standardization" will be the theme of the fifth annual AIEE Appliance Technical Conference which will be held in Chicago, Ill., May 17–19, 1954. Headquarters for this year's conference will be at the Morrison Hotel.

Featured speaker at the meeting will be J. C. Sharp, president of Hotpoint, Inc., who will discuss "Appliance Engineering for Performance" at the opening session on Monday. Of special interest should be the talk on Tuesday by Miss Bernice Strawn, the home equipment editor for the *Woman's Home Companion*, who will consider appliance problems from the customers' viewpoint. Following her talk, Miss Strawn will lead a panel discussion among representatives of both the small and large appliance industries.

In conjunction with the meeting, inspection trips have been scheduled to Hotpoint, Inc., Sears Roebuck and Company Laboratories, and the Dole Valve Company, manufacturers of major appliances; and to the Toastmaster Division of McGraw Electric Company and the Birtman Electric Company, small appliance manufacturers. A tour of Underwriters' Laboratories also is planned.

The program for the 3-day conference is as follows:

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### Monday, May 17

**9:00 a.m. Registration**

**9:30 a.m. Session I**

Presiding: T. C. Johnson, Chairman, AIEE Committee on Domestic and Commercial Applications

Welcome: Professor R. W. Jones, Chairman, AIEE Chicago Section

Address: "Appliance Engineering for Performance." J. C. Sharp, president, Hotpoint, Inc.

**What and How of Standards Groups.** *G. E. Schall, Jr.*, Underwriters' Laboratories

**Standards at Work.** *R. C. Sogge*, General Electric Company

**12 noon. Luncheon**

**1:15 p.m. Session II. Appliance Problems**

Talk: "Appliance Problems From the Customers' Viewpoint." Bernice Strawn, home equipment editor, *Woman's Home Companion*

**Panel Discussion Led by Miss Strawn—**

Members from small appliance industry: C. V. Krichton, Toastmaster Division, McGraw Electric Company; Allen Bate, John Oster Manufacturing Company; W. R. Weeks, General Electric Company

Members from major appliance industry: W. E. Mahaffay, Whirlpool Corporation; H. A. Strickland, Hotpoint, Inc.; G. S. Hill, General Electric Company

**2:45 p.m. Tour of Underwriters' Laboratories**

Transportation by chartered busses

### Tuesday, May 18

**9:00 a.m. Session III. Standardization—Users' Viewpoint**

Presiding: R. W. Fauquet, Sears, Roebuck and Company

**Appliance Servicing and Standardization.** *W. R. Milby*, Detroit Edison Company

**Practical Test of Clothes Dryers.** *W. E. Duvall*, Sears, Roebuck and Company

**Performance Standards for Electric Appliances, Necessary and Desirable.** *H. C. Koenig*, Electrical Testing Laboratories

**Appliance Testing.** *F. J. Schlink*, Consumers' Research, Inc.

**12 noon. Luncheon**

**1:30 p.m. Session IV. Small Appliances**

Presiding: J. A. Deubel, Perfex Corporation

**Vacuum Cleaner Testing** (movie). *G. H. Bramhall*, General Electric Company

**Thermostat Testing and Quality Control.** *F. Stearns*, Metals and Controls Corporation

**Proposed Standards for Heating Appliances.** *B. F. Parr*, Westinghouse Electric Corporation

**Blanket Testing.** *R. G. Holmes*, General Electric Company

**1:30 p.m. Major Appliance Inspection Trips**

Hotpoint, Inc. (Hotpoint busses); Sears, Roebuck and Company Laboratories (chartered busses, attendance limited to first 20 to register for trip); Dole Valve Company (Dole busses)

## Wednesday, May 19

**9:00 a.m. Session V**

Presiding: T. T. Woodson, General Electric Company

**Cordset Testing and Quality Control.** *D. G. Kimball*, General Electric Company

**Contact Sticking.** *Frank Spayth*, P. R. Mallory Company

**Appliance Acceptance Testing From a Utilities' Viewpoint.** *R. C. Bryce, Frank Kahn*, Philadelphia Electric Company

**Timer Testing.** *Leonard Tulauskas*, P. R. Mallory Company

**12:00 noon. Luncheon**

**1:30 p.m. Session VI**

Presiding: N. Cohn, Leeds and Northrup

**Problems in Connecting Appliances to the Potable Water Supply.** *E. J. Zimmer*, Plumbing Testing Laboratories, City of Chicago

**Electronic Range Control.** *H. T. Thunander*, Westinghouse Electric Corporation

**Power Factor Correction of Room Air Conditioners** *G. S. Jones, Jr.*, Air Conditioning and Refrigeration; *H. A. Brysselbout*, York Corporation

**Refrigeration Control Testing.** *L. C. Martin*, General Electric Company

**Automatic Washer Testing.** *R. H. Gabriel*, General Electric Company

**1:30 p.m. Small Appliance Inspection Trips**

Toastmaster Division, McGraw Electric Company (chartered transportation); Birtman Electric Company

**On the serving line for the chicken dinner tendered by members of the Student Branch at Louisiana Polytechnic Institute are, left to right (foreground): E. C. Riall, Jr., secretary - treasurer, Shreveport Section; T. W. Landrum, chairman, Shreveport Section; and J. L. David, chairman of the Student Branch**

## Louisiana Student Branch Entertains AIEE Members

The AIEE Student Branch at Louisiana Polytechnic Institute was host to members of the AIEE Shreveport Section and Monroe Subsection at a meeting and dinner on March 9, 1954.

Student Branch Chairman J. L. David opened the meeting and introduced the Student counselor for 1954–55, M. R. Johnson, Jr. The appreciation of the Section and Subsection for the Student Branch's hospitality was expressed by T. W. Landrum, who also announced the nominees for the coming Institute year: for chairman, E. C. Rial, Jr.; for secretary and treasurer, L. C. Barry; for assistant secretary and treasurer, R. G. Flowers; for the Executive Committee, D. B. Jamison, J. G. Boyd, and C. M. Pons.

Student Member Robert Newell took charge of the introduction of four student papers: "Street Lighting and Its Control," J. L. David; "Transformer Cooling," J. D. Wisterman; "Why Not Electronic Voltage Regulators for Alternators?" B. L. Pourteau; and "Problems of Copper and Aluminum Connectors for Distribution Circuits," S. W. Marshall. After the presentation of the papers, L. T. Williams, chairman of the student paper judging committee, presented the annual award for the best paper to Mr. Marshall.

The barbecued chicken dinner was prepared and served by members of the Student Branch.

## Symposium to View Problems of Electronic Reliability

Designed to consider problems of reliability and quality in electronic components from two angles, the 1954 Electronic Components Symposium already has attracted a great number of early reservations and requests for information, according to M. Barry Carlton, U. S. Department of Defense, chairman of the Symposium Steering Committee.

While the theme of this year's technical meeting is "Technical Progress in Component Development, Fabrication, and Use With Emphasis on New Advances in the Art," the dual approach to the reliability problem will be carried out through the following selective programming techniques:

1. Top-level industry and government officials will discuss component advancements and problems from the executive point of view. Speakers will include Chief Signal Officer G. I. Back; Radio-Electronics-Television Manufacturers Association (RETMA) Board Chairman R. C. Sprague; C. H. Elmendorf of the Bell Telephone Laboratories, Inc.; Dr. D. E. Noble of Motorola Inc.; and R. S. H. Hylkema, Philips Industries, Eindhoven, Holland, who will cover developments abroad.
2. The 3-day meeting will view problems of reliability and quality in electronic design as systems problems rather than those of individual classes of components. Intense interest is being reflected in the technical program for this symposium which was arranged by a committee under A. W. Rogers, Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

The fifth of a series of national meetings on electronic component parts and material, the 1954 symposium will be held at the Department of Interior auditorium in Washington, D. C., on May 4–6. D. A. Quarles, Assistant Secretary of Defense (Research and Development), will deliver the welcoming address at the opening session on May 4. The technical meeting is sponsored jointly by the AIEE, the Institute of Radio Engineers, the RETMA, and the West Coast Electronic Manufacturers Association.

Advance registrations may be made through A. E. Zdobysz, Treasurer, 1954 Electronic Components Symposium, at 1 Thomas Circle, Washington, D. C.

## Program Is Announced for Electric Welding Conference

The AIEE Conference on Electric Welding, in co-operation with the American Welding Society, will be held at Milwaukee, Wis., May 19–21, 1954. It has been arranged by the AIEE Committee on Electric Welding under Chairman E. J. Limpel, A. O. Smith Corporation. Conference headquarters and sessions will be at the Hotel Schroeder.

This is the fourth conference on electric welding and the first to be held outside Detroit, Mich., where previous welding conferences were held during 1948, 1950, and 1952. Milwaukee was chosen this year because of its large and varied industrial users and suppliers of arc and resistance welders and controls. Plant tours

have been arranged at Square D Company, Cutler-Hammer, Inc., Nash Motors, and A. O. Smith Corporation. An evening trip at a brewery is also available.

This year the conference program is aimed at a broad-gauge inquiry into techniques and problems of the electric welding field. Featured will be discussions and the free interchange of information with welding experts. The program is as follows:

## Wednesday, May 19

### Morning. Session 1. Inert Gas Arc

Chairman: E. S. Steinert, Westinghouse Electric Corporation

Secretary: R. K. Sager, Aluminum Company of America

**Power Sources for Consumable Electrode Gas-Shielded Arc Welding.** *A. U. Welch*, General Electric Company

**Inert Gas-Shielded Welding Arc Behavior and Metal Transfer Characteristics.** *G. M. Skinner, D. M. Yenni*, Linde Air Products Company

**Stability and Energy Distribution of Inert Gas Consumable Electrode Arcs.** *H. C. Ludwig*, Westinghouse Electric Corporation

**Radio-Frequency Radiation From High-Frequency Stabilized Arc Welders.** *G. K. Willecke*, Miller Electric Manufacturing Company

### Afternoon. Session 2. Fundamental Arc Research

Chairman: R. J. Krieger, Titanium Metals Corporation of America

Secretary: J. H. Cahn, Battelle Memorial Institute

**Properties of a D-C Arc in a Magnetic Field.** *L. P. Winsor*, Rensselaer Polytechnic Institute; *T. H. Lee*, General Electric Company

**The Atomic Film Cathode in Inert Gas-Shielded Metal Arcs.** *W. J. Greene*, Air Reduction Company, Inc.

**Consumable Electrode Gas-Shielded Welding** (high-speed moving pictures). *R. D. Mann*, General Electric Company

## Thursday, May 20

### Morning. Session 3. Safety

Chairman: G. I. F. Theriault, Frigidaire Division, General Motors Corporation

Secretary: L. C. Poole, Weldtronic Company

**Effect of Capacitor Discharges on the Human Heart.** *W. B. Kouwenhoven*, Johns Hopkins University

**Let-Go Currents and Voltages.** *C. F. Dalziel*, University of California; *P. Massoglia*, San Francisco Naval Shipyard

**Automatic Voltage Reduction of Welding Transformer Open-Circuit Voltage.** *A. J. Davis*, General Electric Company

**Personnel Safety With Industrial Radiography.** *A. F. Cota*, A. O. Smith Corporation

### Afternoon. Session 4. Instrumentation

Chairman: C. R. Dixon, Aluminum Company of America

Secretary: S. M. Kapell, Westinghouse Electric Corporation

**Welding Current Recording on Magnetic Tape.** *Hector Kitscha*, Cutler-Hammer, Inc.

**Practical Instrumentation of Resistance Welding.** *W. E. Large*, Westinghouse Electric Corporation

**The Recording of Welding Variables With Analyzers.** *D. E. Pierce*, Brush Electronics Company

**High-Speed Photography Instrumentation on Arc Welding.** *F. L. Smith*, General Electric Company

## Friday, May 21

### Morning. Session 5. Resistance Welding

Chairman: H. D. Van Sciver, The Budd Company

Secretary: F. L. Brandt, Thomson Electric Welder Company

**Interpretation of Standards for RWMA Type A-1 Transformers as a Basis for Correct Application.** *J. F. Deffenbaugh, V. A. Rathfelder, F. E. Murray*, Federal Machine and Welder Company

**Water Saving and Overtemperature Protection of Welding Control Ignitions.** *J. L. Zehner*, General Electric Company

**Some Problems Encountered in Spot Welding Titanium Alloys.** *R. P. Hurlebaus*, The Budd Company

**Effect of Polyphase Motors on the Voltage Regulation of Circuits Supplying 3-Phase Welder Loads.** *M. A. Faucett, Marvin Fisher, Jr., M. S. Helm*, University of Illinois

## Engineers Joint Council Issues Annual Report for 1953

The Engineers Joint Council (EJC) recently issued its Annual Report for 1953. The report summarizes the year's activities, and includes the EJC constitution, a directory, and a list of the Council's committees for 1954. The organization of the EJC and its development are discussed in an article in this issue of *Electrical Engineering* (*pp. 406–11*) and a list of the officers for 1954 is given also (*p. 482*).

Highlights during the year for EJC included co-operation with the National Science Foundation in the preparation of a National Scientific Register, a selected finders list of perhaps 15,000 to 20,000 engineers. Also, the National Water Power Panel of the EJC has been studying water policy problems and has established relations with government bodies in that field.

Another active project during 1953 has been the program of the Engineering Manpower Commission. One of its principal goals has been that of emphasizing to those who make national manpower policy the special problems involved for engineers and other specialized personnel under both partial and full mobilization.

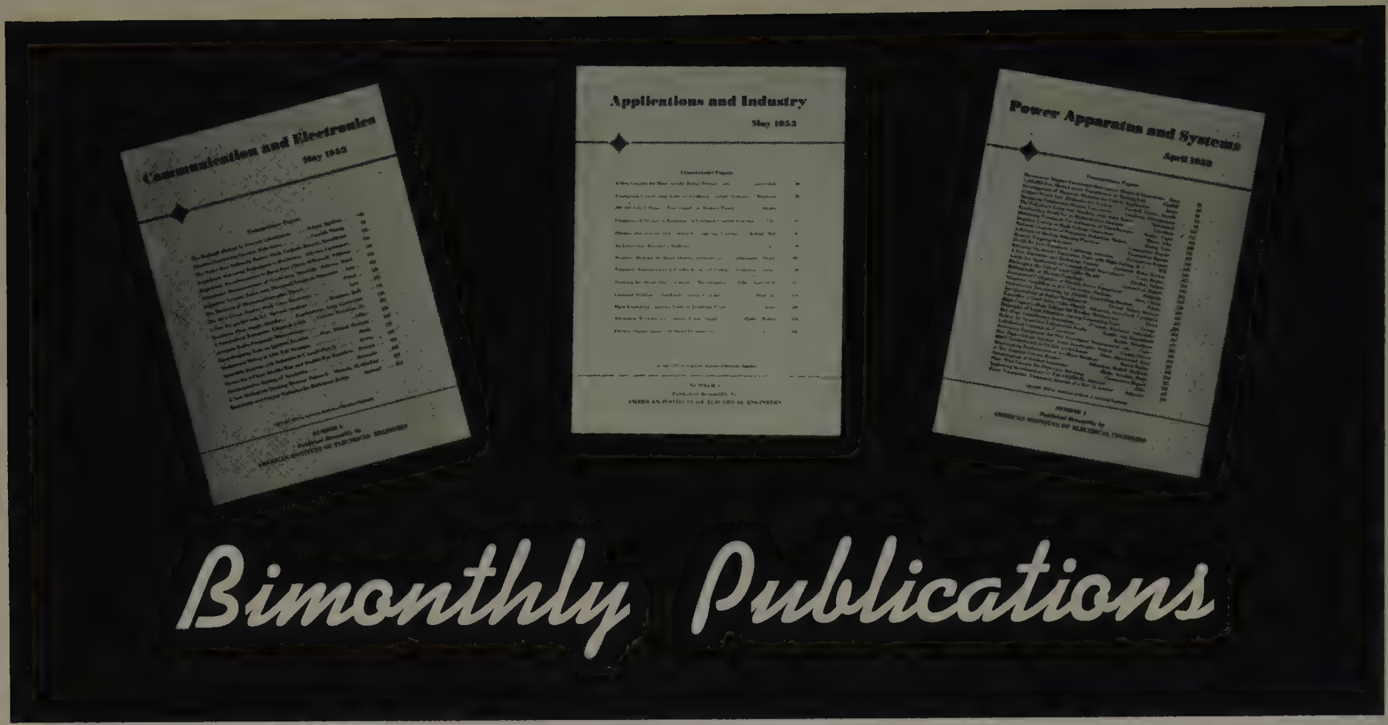
During the year, EJC also prepared and submitted statements in connection with the professional provisions of the Taft-Hartley Act to the Congressional committees studying possible revisions of this law. Other legislative activities include the presentation of a statement before the Joint Committee on Atomic Energy of the Congress with respect to modifying the Atomic Energy Act to permit engineers to make their maximum contribution toward the development of atomic energy for peacetime purposes, and the sponsorship of a bill to amend the 1952 Armed Forces Reserve Act in order to provide for the selective recall of reservists having specialized proficiencies.

Finally, the Special Surveys Committee, in co-operation with the U.S. Office of Education and the Bureau of Labor Statistics, surveyed the demand for engineers and the distribution of the supply of 1953 graduates. The report of that committee is given in full in this issue (*pp. 401–05*).

Anyone specifically interested in further details of the EJC report may obtain copies from Engineers Joint Council, 29 West 39th Street, New York 18, N. Y.

## University of Missouri Career Seminar

**On February 16, 1954, eight members of the AIEE Kansas City Section met with more than 50 faculty and Student members of the Joint AIEE–Institute of Radio Engineers Student Branch at the University of Missouri for the annual career seminar. Shown above, front row, left to right: R. L. Baldwin, Burns and McDonnell Engineering Company; J. S. Palmer, S. H. Pollock, Kansas City Power and Light Company; A. A. Dahms, Allis-Chalmers Manufacturing Company; R. M. Goar, Black and Veatch, Consulting Engineers. Back row, left to right: P. B. Wickersham, Midwest Research Institute; W. B. Thompson, Allis-Chalmers Manufacturing Company; L. M. Shindel, American Telephone and Telegraph Company; R. M. Spillman; K. O. Weiser; W. D. Bird; J. R. Tudor, faculty advisor; J. F. Sutherland**




All of the approved papers presented at General and District meetings are available to members in a series of three bimonthly publications. Technical papers sponsored annually by over 40 different Institute committees have been conveniently grouped in these publications:

**Communication and Electronics**
**Applications and Industry**
**Power Apparatus and Systems**

Most papers appear within 2 to 5 months after presentation. Any discussions are correlated with the papers and immediately follow the texts. The months of issue and the subject matter which appears in the bimonthlies are listed below.

Bimonthly publications have become increasingly popular. Availability on an annual subscription basis enables members to receive the publications without filling in order forms.

Members are entitled to receive without charge one of the three bimonthly publications and may subscribe to the other two at a cost of $2.50 each per year. Nonmember subscription price per publication is $5.00 plus 50 cents extra for foreign postage, both payable in advance in New York exchange. Specify the bimonthly publication desired and send all subscriptions to Institute headquarters. College and public libraries are allowed a 25-per-cent discount on nonmember prices; publishers and subscription agencies, 15-per-cent discount on nonmember prices.

Members who have an actual need for some of the papers on a timely basis are urged to subscribe; however, please do not subscribe merely to discard the material unread. Thoughtfulness in this respect will enable a more efficient distribution to fellow members. The same material will be available at the end of the year in cloth-bound volumes to those who have subscribed in advance to AIEE *Transactions* which are issued in three corresponding parts.

***Standing order subscriptions of members are automatically continued***

**COMMUNICATION AND ELECTRONICS**
**Jan., March, May, July, Sept., Nov.**

Communication Switching Systems
Radio Communications Systems
Special Communications Applications
Telegraph Systems
Television and Aural Broadcasting Systems
Wire Communications Systems
Basic Sciences
Computing Devices
Electrical Techniques in Medicine and Biology
Electronic Power Converters
Electronics
Instruments and Measurements
Magnetic Amplifiers
Metallic Rectifiers
Nucleonics

**APPLICATIONS AND INDUSTRY**
**Jan., March, May, July, Sept., Nov.**

Air Transportation
Domestic and Commercial Applications
Land Transportation
Marine Transportation
Production and Application of Light
Chemical, Electrochemical, and Electrothermal Applications
Electric Heating
Electric Welding
Feedback Control Systems
General Industry Applications
Industrial Control
Industrial Power Systems
Mining and Metal Industry

**POWER APPARATUS AND SYSTEMS**
**Feb., April, June, Aug., Oct., Dec.**

Carrier Current
Insulated Conductors
Power Generation
Protective Devices
Relays
Rotating Machinery
Substations
Switchgear
System Engineering
Transformers
Transmission and Distribution

Education
Safety
Research

## First Petroleum Conference to Be Held in September

An Electrical Conference for the Petroleum Industry is being planned for September 27–29, 1954, at the Mayo Hotel, Tulsa, Okla.

Sponsored jointly by the AIEE Tulsa and Oklahoma City Sections, this first technical conference for the petroleum industry will be supported by the newly formed Petroleum Industry Committee which recently was elevated from subcommittee status. The vital role of electrical engineering in the petroleum industry thus has been recognized.

Papers dealing with electrical aspects of production, transportation, and refining activities are scheduled for presentation. Authors desiring to offer papers or discussions should contact J. Z. Linsenmeyer, chairman of the Petroleum Industry Committee, care of the Westinghouse Electric Corporation, East Pittsburgh, Pa., or R. S. Gardner, assistant secretary for technical committee activities, at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

**The Executive Committee for the Petroleum Conference, seated left to right: R. E. Thornton, incoming chairman, Oklahoma City Section; J. Z. Linsenmeyer; W. H. Stueve, conference chairman. Standing left to right: V. J. Sittel, conference vice-chairman; H. M. Furtney, regional publicity and Tulsa Section chairman**

## Milwaukee Engineers Name Seeger Engineer of the Year

E. W. Seeger (F '36, Member for Life), vice-president of Cutler-Hammer, Milwaukee, Wis., has been named Engineer of the Year for 1953 by the Engineers' Society of Milwaukee (ESM) for his outstanding lifetime record of contributions to the advancement of the engineering profession. ESM President S. J. Gates presented the citation at a dinner on February 24.

Now an AIEE Director, Mr. Seeger served as vice-president of AIEE District 5 from 1948 to 1950. Other engineering activities include the ESM of which he formerly was president and director and the Wisconsin Society of Professional Engineers of which he is a former president. At present he is serving as vice-president of the Central Area for the National Society of Professional Engineers.

Mr. Seeger has been associated with Cutler-Hammer since his graduation from Ohio State University in 1913. He holds approximately 100 patents on electromagnetic devices and control systems.

**E. W. Seeger (right) reads the citation naming him Engineer of the Year which was presented by S. J. Gates (center) for the Engineers' Society of Milwaukee, while the guest speaker Dr. J. R. Dunning (left) looks on**

## Smoker Is Sponsored by Villanova Student Branch

On February 16, 1954, some 43 persons attended a smoker sponsored by the Joint AIEE–Institute of Radio Engineers Student Branch at Villanova University.

The first speaker of the evening was AIEE Vice-President W. B. Morton who discussed the power field, using the new Sunbury Generating Station of the Pennsylvania Power and Light Company as an example. He also discussed the growth and size of the AIEE and the advantages it provides for young engineers.

R. M. Franklin of the Sperry Gyroscope Company was the second speaker. He discussed some of the basic concepts of servo-

**Present at the Villanova smoker were left to right: the Reverend J. A. Klekotka, IRE counselor; E. P. Winkelspecht, vice-chairman, Student Activities Committee, AIEE Philadelphia Section; Professor R. P. Adams, Villanova University; R. M. Franklin; W. B. Morton; Captain M. J. Drury, commanding officer of the Villanova NROTC Unit; J. B. Clothier, AIEE counselor**

mechanisms and their application to marine gyrocompasses and gyropilot steering controls

Also present was E. P. Winkelspecht who represented the AIEE Philadelphia Section.

# COMMITTEE ACTIVITIES

*Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

### Communication Division

**Committee on Marine Transportation** (*W. E. Jacobsen, Chairman; J. E. Jones, Vice-Chairman; W. N. Zippler, Secretary*). The Marine Transportation Committee will act upon matters pertaining to revision of the 1951 edition of AIEE Standard No. *45*, "Recommended Practice for Electric Installations on Shipboard," at its May meeting. Present plans are to issue a revised edition of AIEE No. *45* in December 1954. All revisions and additions, including those adopted at the May 1954 meeting, will be included in this new issue.

### General Applications Division

**Committee on Domestic and Commercial Applications** (*T. C. Johnson, Chairman; H. F. Hoebel, Vice-Chairman; J. H. T. Miller, Secretary*). The popular and successful session on heat pumps and space heating held at the Winter General Meeting indicated the continuing interest of many people in this fast growing field. The many manufacturers beginning actively to develop this field and that of domestic air conditioning should lead to more technical and conference papers on the practical manufacturing and economic aspects to match the extensive technical studies of possibilities that have been made up to now.

The Fifth Annual Appliance Technical Conference will be held at the Morrison Hotel in Chicago, May 17–19, 1954, with the theme "Performance Testing and Standardization." These conferences are organized to give a forum for discussion of technical and practical problems of appliance design, development, and application engineering. In this way the AIEE can be of service to those people who engineer the application of electricity to millions of small tasks in the homes of the nation.

The uses of electricity on the farm have been growing rapidly in recent years and the Subcommittee on Farm Electrification now is arranging a technical conference on the problems and opportunities that arise because of this increase. It is hoped that the conference can be held in September or October with the help of an AIEE Section in the Midwest. This will be the first such conference which has been arranged wholly by the AIEE.

# Engineering Society Presidents Tour Sites

Chicago Tribune photo

**Presidents of five engineering societies with representatives of their boards or councils, about 50 in all, toured suggested building sites in Chicago and Evanston, Ill., as a part of a study for the location of a new Engineering Societies Building. Luncheon was held with Mayor Kennelly as guests of business and civic leaders. In an executive meeting plans for a new site were discussed. Above (left to right) are presidents, L. K. Sillcox, The American Society of Mechanical Engineers; D. V. Terrell, American Society of Civil Engineers; C. G. Kirkbride, American Institute of Chemical Engineers; Mayor Kennelly; Elgin B. Robertson, AIEE. President Leo F. Reinartz, American Institute of Mining and Metallurgical Engineers, who also attended is not shown**

**Committee on Land Transportation** (*Jacob Stair, Jr., Chairman; P. H. Hatch, Vice-Chairman; G. M. Woods, Secretary*). One session with four papers on diesel-electric traction is planned for the Fall General Meeting to be held in Chicago, Ill., October 11–15, 1954. Chicago is a location that should encourage a large attendance of railway electrical engineers.

An effort will be made to devote certain future diesel-electric sessions to a symposium on a topic of especial interest, in the manner that the flashing of diesel-electric motors and generators was discussed at the 1954 Winter General Meeting in New York City.

### Industry Division

**Committee on Industrial Power Systems** (*S. A. Warner, Chairman; R. H. Whaley, Vice-Chairman; R. T. Woodruff, Secretary*). This committee is making good progress on the items reported in the December 1953 issue of *Electrical Engineering* under its "Committee Activities" report on page 1127.

Expanding the practice of having committee members sponsor the technical sessions for General meetings, committee members are doing an excellent job in organizing and presenting interesting sessions. Continuing this practice, the committee has established sponsors from its membership for sessions up to and including the Fall General Meeting of 1955.

The revision of the "Red Book" is progressing well and it is expected to be in the process of printing by the end of this administrative year.

The Subcommittee on Industrial Grounding is in the final stages of review of material which it proposes for consideration as a special publication. This publication is expected to give assistance to circuit designers and operators of industrial plants to aid in providing better grounding for industrial plants.

The committee proposes to hold two joint sessions with the Committee on Transmission and Distribution at the 1954 Fall General Meeting in Chicago on the subject of 265/-460-volt distribution for the supply and use of this voltage in commercial buildings.

### Power Division

**Committee on Substations** (*K. L. Wheeler, Chairman; I. S. Mendenhall, Vice-Chairman; R. F. Lawrence, Secretary*). The papers presented at the 1954 Winter General Meeting brought out a considerable amount of discus-

sion at the session and also written discussions sent to headquarters. None of these papers gave final answers nor were they intended in any way to be standards. They will be, however, of considerable service to the industry in helping the individual engineer determine the basis on which he wishes to design.

The committee now is giving serious consideration to such matters as the design and utilization of mobile substations, extra-high-voltage substations, and the revision of the 1948 "Telemetering, Supervisory Control, and Associated Circuits Reports." This latter work is being done in co-operation with the Group Subcommittee on Telemetering.

**Committee on System Engineering** (*H. L. Harrington, Chairman; A. P. Hayward, Vice-Chairman; H. C. Otten, Secretary*). The Subcommittee on System Operations is sponsoring a group of five papers on the general theme of "System Reliability" for presentation at the AIEE North Eastern District Meeting in Schenectady, N. Y., May 5–7. A program of papers dealing with the subjects of emergency operation of systems at lower than normal frequency and system load relief by automatic or manual means also is being developed by the subcommittee for presentation at the Fall General Meeting in Chicago in October of this year.

The Subcommittee on System Controls is continuing its efforts to make available to the general membership of the AIEE information on the significant developments in the field of automatic frequency and tie-line load control.

The Subcommittee on System Economics sponsored papers, also presented at the 1954 Winter General Meeting, on evaluation and control of energy losses in interconnected power systems.

The Committee on System Engineering expects to add a West Coast Working Group for the purpose of increasing the effectiveness of the committee's work. It is hoped that such a group could meet once or twice a year for discussion of subjects of local interest within the assigned scope of the committee's activities.

### Science and Electronics Division

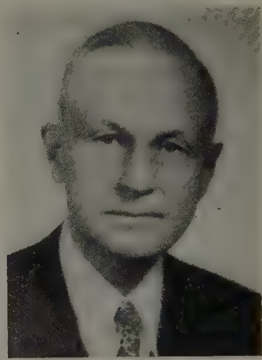
**Committee on Nucleonics** (*G. W. Dunlap, Chairman; W. E. Barbour, Jr., Vice-Chairman; H. W. Bibber, Secretary*). In attempting to provide appropriate coverage of this field for the interests and benefit of the membership, the committee has concluded that its efforts can be directed most effectively toward the sponsoring of special technical conferences, usually in co-operation with other committees of the Institute, and toward the sponsorship at General and District meetings of a few general-interest-type sessions on nucleonics. Attempts to hold highly technical sessions even with invited conference papers have drawn very small attendances.

The committee, however, feels that the importance of the field justifies a continuing and expanding effort to keep the Institute informed of pertinent developments. To this end, a study of the committee structure and activity has been carried on and a reorganization is underway. This is intended to channel the efforts along lines which will be most productive in terms of particular phases of nucleonics which are related to electrical engineering. Under the proposed organization subcommittees will be established to cover the following:

1. Nuclear machines including such items as particle accelerators and radiation sources such as small research reactors (but excluding power reactors).
2. Application of nuclear reactors to the production of power.
3. Nuclear and radiation measurements including instruments, techniques, and applications of radioactive isotope tracers (this subcommittee will be joint with the Instruments and Measurements Committee).
4. In addition, because of the large amount of nucleonic activity carried on on the West Coast, a separate subcommittee will be assigned responsibility for co-ordinating the committee activities in that geographical area.

# AIEE FELLOWS ELECTED..

**Board of Directors Meeting; January 21, 1954**



**John K. Ostrander**

**John K. Ostrander** (AM '10, M '20, Member for Life), consulting electrical engineer, United Engineers and Constructors Inc., Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE "in recognition of extensive contributions made to large industrial and public utility power projects." Mr. Ostrander was born in New York, N. Y., March 2, 1881, and was graduated from Purdue University in 1903 with a bachelor of science degree in electrical engineering. After 4 years with the General Electric Company as a test man in switchboard design and power station layout, he became associated with the New York Central Railroad as an engineer. In 1910 he joined A. L. Drum Company as an engineer and supervised the design of substations and overhead system for a traction company in Hammond, Ind. From 1911 to 1915 he was electrical engineer, Stone and Webster Engineering Corporation. He supervised elctrical design and engineering on the *O* Street power station, substations, and underground cable system for Boston (Mass.) Elevated Railway. As electrical engineer for Electric Bond and Share Company from 1915 to 1920, he supervised electrical design and engineering on hydroelectric plants, substations, and transmission lines for Idaho Power Company, Pacific Power and Light Company, and Utah Power and Light Company. From 1920 to 1928 he was electrical engineer for Dwight P. Robinson and Company, Inc. He was responsible for the direction of as many as 25 electrical engineers and 200 draftsmen who performed the engineering and design of numerous large projects. He also co-ordinated electrical design with mechanical and structural design. Since 1929 he has been consulting electrical engineer, United Engineers and Constructors, Inc. In addition to responsibilities similar to those he assumed for Dwight P. Robinson, Mr. Ostrander directed engineering studies and preparation of reports with engineers and management of large industrial and public utility companies on over-all electrical programs. He also acted as a consultant to a department of 25 electrical engineers on advanced engineering problems in transmission, system stability, and analysis of electric furnace circuits. Mr. Ostrander holds patents on a key interlock system, speed control system for large induction motors, liquid rheostat, water heater control, and self-supporting aerial cable. He is a member of the Association of Iron and Steel Engineers.

# AIEE PERSONALITIES.....

**C. J. Simon** (AM '43), district sales manager, broadcast equipment, General Electric Company, New York, N. Y., has been appointed manager of product planning for broadcast equipment, commercial equipment department, Syracuse, N. Y. Mr. Simon is a native of Syracuse and a graduate of Syracuse University. He joined General Electric in 1942 as a student engineer, subsequently serving at Erie, Pa.; Syracuse, and Schenectady, N. Y. In 1944 he became a field engineer on military equipment, was transferred to commercial equipment in 1945, and became supervisor of field engineering for the commercial equipment department in 1948. He was transferred to sales work in 1949 and became district sales manager for broadcast equipment at New York City in 1950.

**J. D. Heibel** (AM '34, M '46), director of research and engineering, Erie (Pa.) Resistor Corporation, has been named vice-president

in charge of research and engineering. Mr. Heibel joined Erie Resistor in 1936, having been in the engineering department of Talon, Inc., Meadville, Pa., and was manager of the Condensor Division. In 1945 he became manager of sales engineering and since 1949 has served as director of research and engineering. Mr. Heibel is a graduate of the University of Pittsburgh, is a member of the Institute of Radio Engineers, and is chairman of the Radio-Electronics-Television Manufacturers Association Committee on Ceramic Dielectric Capacitors. Mr. Heibel has served on the AIEE Committees on Electronics (1947–49, 1952–53) and Basic Sciences (1953–54).

**J. G. Reid, Jr.** (AM '46, M '48), director, Electronics Division, National Bureau of Standards, Washington, D. C., has been appointed general manager of ACF Electronics, a division of American Car and Foundry Company, Alexandria, Va. Mr. Reid has served on the following AIEE committees: Electronics (1947–54); Instruments and Measurements (1948–54, Chairman, 1953–54); Electrical Techniques in Medicine and Biology (1951–52); and Science and Electronics Division (1952–54).

**R. G. Dobbin** (AM '46), design engineer, Jack and Heintz, Inc., Cleveland, Ohio, has been named manager, commercial engineering section. Mr. Dobbin joined Jack and Heintz early in 1953. He holds a bachelor of science degree in electrical engineering from the Milwaukee School of Engineering. For more than 10 years he served as a designer of fractional-horsepower motors with the General Electric Company, Fort Wayne, Ind. Prior to joining Jack and Heintz he was acting as motor consultant for International General Electric at Schenectady, N. Y., and in Brazil.

**R. R. Stevenson** (AM '18), assistant district manager, Philadelphia (Pa.) sales office, I-T-E Circuit Breaker Company, retired December 31, 1953. For the last 5 years, Mr. Stevenson has been assistant district manager of the Philadelphia office. For 20 years before that he was district manager of the Philadelphia office of Railway and Industrial Engineering Company and before that, chief engineer of Electrical Development and Machine Company in Philadelphia. Mr. Stevenson started as an electrical engineer in the power utility field, having graduated in electrical engineering at Cooper Union in 1915. He was successively with New York Edison Company, Montreal Light Heat and Power Company, Montreal Engineering Company, and Hydro-Electric Power Commission of Ontario.

**C. C. Chambers** (AM '35, F '51), dean, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, has been elected vice-president of the university in charge of engineering affairs. He has headed the Moore School of Electrical Engineering since 1949—as acting dean until 1951, since then as dean. As vice-president he will be responsible for chemical, civil, mechanical, metallurgical, and electrical engineering education. Dr. Chambers, graduated from Dickinson College in 1929, joined the university's teaching staff in 1933, and earned the degree of doctor of science in engineering a year later. During World War II he guided the training of more than 6,000 students in the Moore School's Engineering Science Management War Training program. While doing this he also organized and operated, in 1943, a research project of the Office of Strategic Services, for which he was awarded the Army and Navy Certificate of Appreciation. He also was technical consultant in most of the Moore School's war research. Dr. Chambers has patents in fields ranging from electronics to the printing industry. He has served as a Liaison Representative on the AIEE Standards Committee (1951–54).

**M. F. Smalley** (M '48), superintendent of meters, Ohio Power Company, Canton, retired January 1, 1954, following more than 43 years of service with Ohio Power and affiliated companies. Mr. Smalley was born in Wabash County, Ind., on October 10, 1891, and attended Marion Normal College. In 1910 he went to work for the Muncie (Ind.) Electric Light Company as a switchboard builder. From January 1911 to April 1916, he worked as general foreman in the line and meter department, Hartford City, Ind. He went back to Marion Normal College on a leave of absence from April 1916 to August 1917. From that date to February 1923, he served as meter superintendent at Newark, Ohio, first for the Ohio Light and Power Company, then the Central Power Company, and finally the Ohio Power Company. For a year he served as field meter engineer for American Gas and Electric, Canton, Ohio. He was named general meter superintendent of Ohio Power at Canton in 1927 and in 1932 was appointed superintendent of meters and services. Mr. Smalley is a past chairman of the Ohio chapter of the International Association of Electrical Inspectors and the Inspectors Association. He also is past chairman of the meter committee of the National Electric Light Association.

**C. L. Lucal** (AM '47, M '53), assistant superintendent of meters, Ohio Power Company, Canton, has been appointed superintendent of meters. Mr. Lucal joined Ohio Power in 1933 as a meterman in the former Canton Division. In 1935 he was named a meterman in the Canton general office. Two years later he became a meter engineer and in 1938 he was named assistant superintendent of meters. Prior to joining Ohio Power, he worked for the Cleveland Electric Illuminating Company, National Tube Company, Lorain, Ohio, and the Ohio Public Service Company. Mr. Lucal is a member of the International Association of Electrical Inspectors.

**H. E. Hershey** (AM '11, M '21, Member for Life), supervisor of technical publications, Automatic Electric Company, Chicago, Ill., retired January 31, 1954. Mr. Hershey joined the company in 1910. In 1915 he joined the Tri-State Telephone and Telegraph Company at Minneapolis–St. Paul, Minn. During World War I he served as a signal officer in an infantry division. Returning to Automatic Electric after the war, he spent some time in the factory inspection department, then went to the laboratories as a circuit designer for 12 years. Since 1938 he has been head of the technical publications group. Mr. Hershey received his bachelor of science and electrical engineer degrees from Kansas State College and his bachelor and doctor of laws degrees from John Marshall Law School. He is a member of the Illinois and American Bar Associations and the Western Society of Engineers. He has served on the AIEE Committee on Communication.

**W. R. Hough** (AM '35, F '48), engineering vice-president, Reliance Electric and Engineering Company, Cleveland, Ohio, has been elected a director of the company. Mr. Hough joined Reliance upon graduation from the University of Michigan in 1929, successively holding several positions in the engineering organization which led to his election as engineering vice-president in 1948. He is a past president of the Cleveland Technical Society's Council, and a member of Tau Beta Pi, Association of Iron and Steel Engineers, and the Cleveland Engineering Society. He is chairman of the Cleveland Section of the AIEE and has served on the following Institute committees: Electrical Machinery (1942–47); Sections (1945–47, 1953–54, Chairman, 1953–54); Rotating Machinery (1947–53, Chairman, 1949–51); Transfers (1948–51); Standards (1949–54); Technical Program (1949–50); Power Division (1949–51); and Management (1952–53).

**C. J. Breitwieser** (AM '33, M '44), director of engineering and manager of the General Development and Engineering Division, Lear, Incorporated, Los Angeles, Calif., has been elected a vice-president of the company. Dr. Breitwieser recently came to Lear from P. R. Mallory and Company, Inc., Indianapolis, Ind., where he was director of engineering in charge of the central engineering laboratories. Prior to joining Mallory, he was with Convair for over 9 years as chief of Electronics and Research Laboratories, responsible for the electronics and guidance section, guided missile flight test section, engineering test laboratories, and the missile and airplane instrumentation section. Dr. Breitwieser has served on the AIEE Committees on Air Transportation (1944–48) and Electronics (1948–54).

**S. B. Lent** (M '43), chief electrical engineer, Metropolitan Transit Authority, Boston, Mass., has been promoted to superintendent of power. Mr. Lent joined the Boston Elevated Railway in 1924 as an assistant in the electrical engineering section and worked his way up to the position of chief electrical engineer by 1945. He was retained in that capacity by the Metropolitan Transit Authority which absorbed the railway in 1947. Mr. Lent is a member of the American Transit Association, Society of Professional Engineers, and the American Ordnance Association. He is serving on the AIEE Committee on Land Transportation (1948–54).

**C. W. Wilson** (AM '40), assistant branch manager, Exide Industrial Division, The Electric Storage Battery Company, Chicago, Ill., has been appointed branch manager. Mr. Wilson began his career as an office boy in 1915 at the firm's Cleveland, Ohio, depot. In 1918 he became chief clerk at Cleveland, and the following year he was transferred to Kansas City, Mo., branch as a sales engineer. He was made branch manager at Dallas, Tex., in 1939, and became assistant manager of the Chicago branch in 1946.

**C. T. Kastner, Jr.** (AM '50), supervisor of medium transformer sales, General Electric Company, Pittsfield, Mass., has been appointed manager of transformer apparatus sales. A graduate of Yale University, he joined General Electric in 1946 on the test program. Following assignments in Lynn, Mass., and Schenectady, N. Y., he came to power transformer sales at Pittsfield in 1947. On January 1, 1952, he was appointed supervisor of traveling specialists and later supervisor of medium transformer sales.

**George Friedl, Jr.** (M '38), works manager, Link Aviation, Inc., Binghamton, N. Y., has been named vice-president in charge of manufacturing. Mr. Friedl joined the firm as works manager about a year ago, having formerly been executive vice-president, Technical Industries, Inc., Pasadena, Calif. A graduate of Cooper Union, he was with the Western Electric Company from 1928 to 1937. From 1937 to 1950 Mr. Friedl was associated with the General Precision Equipment Corporation. He served as director of engineering for a subsidiary, the International Projector Corporation, and later was president and director of Librascope, Inc., another subsidiary. During World War II he was executive officer with the Naval Research Laboratory, Washington, D. C. He is a fellow in the Society of Motion Picture and Television Engineers, and a member of the American Ordnance Association and the Acoustic Society of America.

**C. H. Bartlett** (AM '52), assistant manager, Transformer Division, Westinghouse Electric Corporation, Sharon, Pa., has been appointed manager of the Manufacturing and Repair Division. Mr. Bartlett was born in Bessemer, Ala., and was graduated from the University of Colorado in 1928 with the degree of bachelor of science in electrical engineering. He joined the Westinghouse graduate student training course that same year and after a brief period in sales at East Pittsburgh, Pa., was transferred to Emeryville, Calif., in the transformer sales department. In 1942 he moved to the sales department at Transformer Division headquarters, Sharon, where 2 years later, he became manager of the instrument and specialty department sales section. After heading the specialty transformer department in 1946, he was named sales manager for the Division in 1949. Mr. Bartlett managed the Transformer Division from 1952 until late 1953 when he was chosen to attend the Harvard School for Advanced Management for a 3-month period. He returned as assistant division manager until his new appointment.

**V. H. Disney** (M '50), assistant manager, electrical engineering department, Armour Research Foundation, Chicago, Ill., has been named manager of the electrical engineering research department. Mr. Disney jointed the Foundation staff in 1949, serving first as supervisor of the electronics section. He was promoted to assistant manager of the electrical engineering department in 1951. Before coming to the Foundation, Mr. Disney was a project engineer with Sperry Gyroscope Company, Great Neck, N. Y. He was with Curtiss-Wright Corporation, Dayton, Ohio, from 1946 to 1947, serving as assistant section head of research. From 1943 to 1946 he was a project engineer for C. G. Conn, Ltd., Elkhart, Ind. In 1942–43, he taught in the Engineering Science Management War Training program at Illinois Institute of Technology, Chicago, and from 1937 to 1942 he was an electrical engineer for American Can Company, Chicago. Mr. Disney was graduated from the University of Missouri in 1936. He is a senior member of the Institute of Radio Engineers and a member of Eta Kappa Nu and Tau Beta Pi.

**C. B. Stott** (AM '50), International Business Machines Corporation, Endicott, N. Y., has been appointed technical engineer in production engineering. Mr. Stott began his association with International Business Machines in 1949 when he was hired as a customer engineer in Boston, Mass. In December of that year he was assigned to Customer Engineering School in Endicott. On completion of his training period, he was assigned to the Boston sales office as a customer engineer. In November 1950, he was transferred to the Endicott Engineering Laboratory for an assignment in production engineering and held that position until the time of his new appointment. Mr. Stott was born in Wollaston, Mass., and after attending Brown University and Clark University, graduated from Tufts College in 1949 with a bachelor of science degree in electrical engineering. He is a member of Tau Beta Pi.

**W. A. Ready** (AM '16, M '28, Member for Life), chairman of board and president, National Company, Malden, Mass., has been elected to the board of directors of Browning Laboratories, Inc., Winchester, Mass. Mr. Ready has served on the AIEE Committees on Communication (1947–49) and Special Communication Applications (1949–53).

**C. P. Wood** (AM '11, M '13, Member for Life), industrial engineer, Lockwood Greene Engineers, Inc., New York, N. Y., contributed the article on "Factory Construction and Planning" in the current edition of "Encyclopaedia Britannica."

**H. F. Hoebel** (AM '41, M '47), senior engineer, electrical engineering department, American Gas and Electric Service Corporation, New York, N. Y., has been named assistant electrical engineer. Mr. Hoebel has been associated with the electrical utility industry since 1926 and with the Service Corporation since 1947. Named a senior engineer in 1952, he holds an electrical engineering degree from the University of Wisconsin. Mr. Hoebel is serving on the AIEE Committee on Domestic and Commercial Applications (1951–54).

**J. E. Geue** (AM '22), plant consultant, American Gas and Electric Service Corporation, New York, N. Y., has been named manager—production. Mr. Geue joined the American Gas and Electric system at its Windsor Plant in 1922. He was superintendent of the system's Stanton Plant, Scranton, Pa., at the time he was transferred to the Service Corporation as a plant consultant in 1946. He has a degree in hydroelectric engineering from Washington State College.

**F. M. Porter** (AM '36, M '45), electrical equipment section head, American Gas and Electric Service Corporation, New York, N. Y., has been appointed electrical engineer. Mr. Porter has been head of the electrical equipment section since 1945 and before that was a substation engineer. He joined American Gas and Electric in 1926 and holds an electrical engineering degree from Lehigh University. He is serving on the AIEE Committee on Rotating Machinery (1953–54).

**J. H. Kinghorn** (M '46), assistant electrical engineer, American Gas and Electric Service Corporation, New York, N. Y., has been promoted to deputy electrical engineer. Mr. Kinghorn joined the Wheeling Electric Company, a subsidiary of American Gas and Electric, in 1926. He was transferred to the parent company in 1928, became head of its protection and control section in 1946 and assistant electrical engineer in 1950. He is an electrical engineering graduate of Carnegie Institute of Technology. Mr. Kinghorn has served on the following AIEE committees: Protective Devices (1947–49); Relays (1947–52); and Power Generation (1953–54).

**F. A. Lane** (AM '19, M '31), electrical engineer, American Gas and Electric Service Corporation, New York, N. Y., has been appointed deputy chief engineer. Mr. Lane has been electrical engineer in charge of the Electrical Engineering Division since 1945. He joined the company in 1925 and holds electrical engineering degrees from both Massachusetts Institute of Technology and Harvard University. Mr. Lane has served on the following Institute committees: Switchgear (1947–54, Chairman, 1948–50); Power Co-ordinating (1948–50); Standards (1948–50); and Technical Program (1948–50).

**H. P. St. Clair** (AM '22, F '44), system planning engineer, American Gas and Electric Service Corporation, New York, N. Y., has been named planning and operating engineering manager. Mr. St. Clair joined American Gas and Electric in 1924 and has been engaged in the company's system planning work ever since. He became system planning engineer in 1950. He received his electrical engineering degree

from California Institute of Technology. Mr. St. Clair has served on the following AIEE committees: Protective Devices (1940–45); Board of Examiners (1952–54); and Transmission and Distribution (1952–54).

**V. M. Marquis** (AM '23, M '31), vice-president—system operation and planning, American Gas and Electric Service Corporation, New York, N. Y., has been named vice-president and assistant to the president. Mr. Marquis has been associated with American Gas and Electric since 1928, except for a period with the War Production Board, during World War II. He had been vice-president in charge of system planning and operation since 1950 and before that was system planning and operating engineer. He holds mechanical and electrical engineering degrees from Stanford University and a master of science degree in electrical engineering from Union College. Mr. Marquis has served on the AIEE Committees on Power Generation (1940–45) and System Engineering (1947–49).

**J. C. Gibbs** (AM '43), assistant vice-president, Citizens Utilities Company, Greenwich, Conn., has been elected vice-president of the company with full responsibility for operating and engineering activities. Mr. Gibbs has been affiliated with the company since 1950. **T. J. Woods** (AM '48), electrical engineer, Chicago, North Shore, and Milwaukee Railway Company, Highwood, Ill., has joined Citizens Utilities as assistant to the vice-president.

**A. J. Rynkus** (AM '52), design engineer, International Business Machines Corporation, Endicott, N. Y., has been named a technical engineer in the defense engineering publications department. **M. P. Prater** (AM '47), designer, defense development engineering department, has been promoted to the position of technical assistant, card engineering department. Mr. Rynkus is a native of Chicago, Ill., and was graduated from Illinois Institute of Technology with bachelor of science degrees in both mechanical and electrical engineering. He has been with International Business Machines since 1951 and is a member of Tau Beta Pi, Pi Tau Sigma, and Eta Kappa Nu. Mr. Prater, a native of Webster City, Iowa, graduated from Iowa State College with a bachelor of science degree in electrical engineering. He began his association with International Business Machines in 1946 as a member of the engineering training program. After completion of this training he was assigned to development engineering and in 1951 was transferred to defense development engineering. During World War II he served in the U. S. Navy.

**H. M. Finlayson** (M '44), assistant manager, hydraulic resources department, The Shawinigan Water and Power Company, Montreal, Que., Canada, has been appointed manager of the department. Mr. Finlayson has been assistant manager since 1950. During World War I he served with the Royal Flying Corps. Returning, he attended McGill University and graduated in civil engineering in 1923, then joined the St. Lawrence Deep Waterway Commission. In 1928 he joined The Shawinigan Engineering Company Limited and for 2 years led a hydrographic survey party in measuring the flow of the St. Maurice River at sites which have been developed since or planned for hydroelectric power generation. In 1930 he was transferred to the generation and transmission department of the parent power company to undertake studies of water storage and potential power sites on many rivers in Quebec. Mr. Finlayson is vice-president of the International Eastern Snow Conference, and a member of the Arctic Institute of North America, the American Geophysical Union, the Engineering Institute of Canada, the American Society of Photogrammetry, and the Corporation of Professional Engineers of the Province of Quebec.

**J. P. Hutcheson, Jr.** (AM '40), manufacturer's representative, Master Electric Company, Cleveland, Ohio, has joined Jack and Heintz, Inc., Cleveland, as an application engineer of the commercial motor section. He has been assigned the Ohio-Pennsylvania territory, operating out of Cleveland. A native of McKeesport, Pa., Mr. Hutcheson received his electrical engineering degree at Pennsylvania State College. He is a member of the Cleveland Engineering Society.

**M. J. Gross** (AM '53), manager, technical general section, Knolls Atomic Power Laboratory, General Electric Company, Schenectady, N. Y., has been appointed director of engineering, Ritter Company, Inc., Rochester, N. Y. Mr. Gross received his bachelor of science degree in electrical engineering at Oregon State College in 1928. He was awarded a master of science degree in physics from Union College in 1930. From 1928 to 1942 Mr. Gross was concerned with the development of General Electric X-ray tubes and apparatus. As vice-president in charge of engineering of the General Electric X-Ray Corporation, Mr. Gross founded the Coolidge Development Laboratory and introduced new lines of X-ray equipment for civilian and military use. More recently, he has been manager of the technical general section of the Knolls Atomic Power Laboratory, where he organized the Radioactive Materials Laboratory. Mr. Gross served as a major in the Medical Administrative Corps of the U. S. Army from 1942 to 1945. He has headed committees of the Western Society of Engineers and the National Electrical Manufacturers Association. He is a registered professional engineer in Wisconsin, and a member of the American Management Association, the American Institute of Management, Sigma Xi, Eta Kappa Nu, Tau Beta Pi, Sigma Tau, and Phi Kappa Phi. He has served on the AIEE Committee on Therapeutics (1949–50).

**E. S. Winlund** (AM '52), electronics engineer, Westinghouse Electric Corporation, Hartford, Conn., has been appointed chief engineer, Gray Research and Development Company, Inc., Hartford. Mr. Winlund also has been associated with the Radio Corporation of America. He is a graduate of the University of California and was a General Electric Company co-operative student at Massachusetts Institute of Technology. He is a member of Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and the Institute of Radio Engineers.

## OBITUARIES • • • •

**Frank Wenner** (AM '12, M '14, F '26, Member for Life), consulting physicist, National Bureau of Standards, Washington, D. C., died February 7, 1954. Dr. Wenner was born in Garrison, Iowa, January 18, 1873, and was graduated from Knox College in 1899 with a bachelor of science degree. Until 1907 he taught at Knox College, University of Wisconsin, Iowa State College, and the University of Pennsylvania. He received a doctor of philosophy degree from the University of Pennsylvania in 1909. In 1942 he was awarded an honorary doctor of science degree by Knox College. Dr. Wenner joined the Bureau of Standards in 1909. He had been chief of the resistance measurements section for 30 years when he retired in 1943. After retirement he served as a consultant with the Carnegie Institute of Washington, the Applied Physics Laboratory of Johns Hopkins University, and the Research and Development Board of the Department of Defense. He returned to the Bureau in 1951 as a full-time consultant on a classified project and worked at the Bureau and at the Diamond Ordnance Fuze Laboratory. During his career he acquired an international reputation both in electrical measurements and in geophysics. He developed a method for measuring the salinity of sea water for the U. S. Coast Guard. His work on electrical resistance measurements included the development of a fundamental method for measuring the unit of resistance. Dr. Wenner was awarded the John Price Wetherill Medal of the Franklin Institute for his work on seismology and for the development of the very precise electric seismometer which bears his name. He was a fellow of the American Physical Society and the American Association for the Advancement of Science and a member of the Washington Academy of Sciences, the Philosophical Society of Washington, the Geological Society of Washington, the American Geophysical Union, and Sigma Xi. He had served on the AIEE Committee on Standards (1923-28).

**Douglas Smith Anderson** (AM '01, M '36, Member for Life), dean emeritus, School of Engineering, Tulane University, New Orleans, La., died March 2, 1954, in New York, N. Y. Dr. Anderson retired in 1936 after spending 44 years as a member of the university's faculty. Upon his retirement he was named professor of electrical engineering emeritus and dean emeritus of the school of engineering. Dr. Anderson was born in Lexington, Va., September 6, 1871 and was graduated from Washington and Lee University in 1890 with a bachelor of arts degree. In 1892 he was awarded a master of arts degree from Tulane University

and in October of that year was appointed instructor in physics. He was named assistant professor of physics in 1893 and in 1898 was appointed associate professor of physics and electrical engineering. In 1900 he was elected professor of electricity and electrical engineering at the University of Mississippi, Oxford. He returned to Tulane in 1901 and in 1909 he was named professor in electrical engineering. In 1919 he was named dean of the school of engineering. In February 1934 he was designated to act as president of Tulane during the illness of its president. In July 1936 he retired as professor of electrical engineering, head of the school of engineering, and acting president. Dr. Anderson was awarded an honorary degree of doctor of science by Washington and Lee in 1933 and an honorary doctor of laws degree from Tulane in 1937. He was a former president of the Louisiana Engineering Society and the Society for the Promotion of Engineering Education. He was a member of the American Association for the Advancement of Science.

**James Bowie White** (M '40), resident electrical engineer, American Section, International Boundary and Water Commission, El Paso, Tex., died November 28, 1953. Mr. White was born in Matagorda, Tex., February 17, 1880, and was graduated from the University of Texas in 1906. For many years he was construction superintendent for Stone and Webster Engineering Corporation, engaged in the construction of generation and transmission facilities for the El Paso Electric Company. Since 1934 he had been resident engineer for the International Boundary and Water Commission and for the few years prior to his death, he was associated with the design and construction of the Falcon Dam on the Rio Grande.

**Fay N. Floyd** (AM '16, M '22, Member for Life), vice-president and director, United Engineers and Constructors, Inc., Philadelphia, Pa., died February 9, 1954. Mr. Floyd was born on October 12, 1892, in Mancos, Colo., and was graduated from the University of Colorado in 1914 with a bachelor of science degree in electrical engineering. He served in the U. S. Army in World War I. In 1920 he joined the Dwight P. Robinson Company in New York, N. Y. In 1928 this company merged to form United Engineers and Constructors, Inc., and Mr. Floyd was made production engineer, and in 1943 engineering manager. He was named vice-president and director a year ago.

**Walter Roy Jones** (M '49), professor of electrical engineering, Cornell University, Ithaca, N. Y., died March 8, 1954. Mr. Jones also was a nationally known expert on vacuum tube design and construction. Born in Ossining, N. Y., August 9, 1902, he was graduated from Cornell in 1925 with a degree in electrical engineering. After graduation he joined the Federal Radio Corporation, Buffalo, N. Y., as a test engineer. He later became chief engineer and when he left the company in 1929 he was in charge of research and development. From 1929 to 1948 he was with Sylvania Electric Products, Inc., Emporium, Pa. Starting as a sales engineer with Sylvania, he moved up to become chief engineer of the radio tube division. In 1948 he became assistant professor of electrical engineering at Cornell. He was made a full professor in 1951. From 1948 to 1953, as co-ordinator for research in the school of electrical engineering, he played a major role in the school's development and research program. He was chiefly responsible for the establishment of the school's vacuum tube laboratory. Since 1951 he had directed studies in the laboratory for the Army Signal Corps which are expected to lead to the production of more reliable vacuum tubes. Mr. Jones was a senior member of the Institute of Radio Engineers and a member of the Society of Motion Picture and Television Engineers. He was a fellow of the Radio Club of America.

**Edwin Francis Wood** (M '36), division operating superintendent, New York State Electric and Gas Corporation, Elmira, died May 18, 1953. Mr. Wood was born in Troy, Pa., October 14, 1896. He graduated from Bliss Electrical School and entered the employ of the utility company at Elmira in 1922 as electrical engineer. In 1938 he was transferred to Hornell to head the engineering department and in 1943 was brought back to Elmira as division operating superintendent. He was a professional engineer in New York and Pennsylvania and was past president of the Steuben area of the New York State Society of Professional Engineers.

**Edwin Nesbitt Harman** (AM '21, M '48), retired, Geneva, N. Y., died November 21, 1953. Mr. Harman had retired as chief testman, long lines department, New York Telephone Company, Geneva, in 1952. He was born in Ogdensburgh, N. Y., October 31, 1887. After 15 years' experience with various independent telephone companies, he joined the New York Telephone Company in Geneva in 1918, serving as wire chief, chief automatic switchman, and chief testman before his retirement.

# MEMBERSHIP • • •

## Recommended for Transfer

The Board of Examiners at its meeting of March 18, 1954, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

### To Grade of Member

Allen, O. T., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Barber, H., asst. electrical engineer, New England Power Service Co., Boston, Mass.
Barnes, R. F., sales manager, General Electric Co., Philadelphia, Pa.
Brock, T. R., manager, Jackson Office, General Electric Co., Jackson, Miss.
Carlisle, B. H., electrical engineer, Clark Controller Co., Cleveland, Ohio
Chinn, N. W., electrical engineer, Dominion Rubber Co., Ltd., Montreal, Que., Canada
Coleman, W. E., research associate, United States Steel Corp., Pittsburgh, Pa.
Cross, R. J., general superintendent, Consolidated Edison Co. of New York, Staten Island, N. Y.
Doughty, W. E., assistant equipment engineer, The Home Tel. & Tel. Co., Fort Wayne, Ind.
Dupuis, J. J., electrical superintendent, Consolidated Paper Corp., Ltd., Shawinigan Falls, Que., Canada
Edwards, W. E., electrical branch manager, public works office, 14th Naval District, Pearl Harbor, T. H.
Eichner, R. M., manager, apparatus sales div., General Electric Co., Corpus Christi, Tex.
Eidson, L. U., consulting & application engineer, Westinghouse Electric Corp., Houston, Tex.
Green, H. H., engineering administration manager, General Electric Co., Utica, N. Y.
Hausle, F. T., distribution design engineer, Long Island Lighting Co., Mineola, N. Y.
Heiss, F. S. D., transmission engineer, Bell Telephone Co. of Pennsylvania, Philadelphia, Pa.
Henry, W. S. C., assistant engineer, New England Power Service Co., Boston, Mass.
Kegel, A. G., project engineer, Westinghouse Electric Corp., Baltimore, Md.
Kerner, J. R., distribution apparatus manager, Westinghouse Electric Corp., New York, N. Y.
Knapp, T. F., motor project engineer, Lear, Inc., Grand Rapids, Mich.
Koenig, L. A., electrical engineer, Clark Controller Co., Cleveland, Ohio
Larson, W. M., chief engineer, Control Corp., Minneapolis, Minn.
La Sota, L. S., foreman, H. V. laboratory, Pennsylvania Transformer Co., Canonsburg, Pa.
Lenz, H. R., engineer, Philadelphia Electric Co., Philadelphia, Pa.
Linden, E. E., assistant engineer, The Narragansett Electric Co., Providence, R. I.
Love, C. O., meter & relay superintendent, Texas Power & Light Co., Dallas, Tex.
Martinez D'Meza, H., works manager, Industrial Electrica de Mexico, S.A., Mexico, D.F., Mexico
Meyers, B. C. H., engineer, Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Mulligan, J. H., Jr., chairman, electrical engineering dept., New York University, New York, N. Y.
Pumphrey, O. F., engineer, Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Ramirez, J. E., design engineer, Jackson & Moreland, Engineers, Boston, Mass.
Randle, L. V., plant electrical engineer, Temco Aircraft Corp., Dallas, Tex.
Raven, G. F., chief engineer, Kirkhof Electric Co., Grand Rapids, Mich.
Renoff, P. V., partner, Paul V. Renoff Co., Baltimore, Md.
Roberts, F. B., project electrical engineer, Austin Engineers, Inc., Detroit, Mich.
Schurr, C. A., assistant chief engineer, National Acme Co., Cleveland, Ohio
Serna Silva, F., chief engineer, Ingenio Tamazula, S.A., Tamazula, Jal., Mexico
Skiles, A. F., Jr., electrical engineer, Bechtel Corp., Los Angeles, Calif.
Spayd, R. S., electrical engineer, Gilbert Associates, Inc., Reading, Pa.
Stephens, W. P., electrical engineer, National Supply Co., Springfield, Ohio
Streever, O. J., corrosion research engineer, Newport News Shipbuilding & Drydock Co., Newport News, Va.
Tims, E. F., electrical engineering dept., Washington Univ., St. Louis, Mo.
Tragesser, H. R., engineering section manager, Jack & Heintz, Cleveland, Ohio
Walker, B. G., vice-president, Control Corporation, Minneapolis, Minn.
White, H. D., senior electrical engineer, public works dept., State of California, Sacramento, Calif.
Willoch, H., senior electrical engineer, Sverdrup & Parcel, Inc., St. Louis, Mo.
Windham, J. W., district superintendent, Alabama Power Co., Oneonta, Ala.
Winslow, J. C., design engineer, Electric Auto-Lite Co., Toledo, Ohio

48 to grade of Member

## Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before May 25, 1954, or July 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

### To Grade of Member

Beique, H. F., Quebec Power Co., Quebec City, Que., Canada
Bowman, L. H., Columbia Broadcasting System, Inc., Los Angeles, Calif.
D'Amours, M., Quebec Power Co., Quebec City, Que., Canada
Davey, E. L., W. T. Glovers & Co. Ltd., Manchester, England
Fetter, T. S., Jr., Philadelphia Electric Co., Philadelphia, Pa.
Hollingsworth, D. T., British Insulated Callenders Cables, Ltd., London, England
Kelly, G. F., Quebec Power Co., Quebec City, Que., Canada
Nixon, G. M., J. H. Lock & Sons, Ltd., North Vancouver, B. C., Canada
Northrup, G. E. (re-election), The Scranton Electric Co., Scranton, Pa.

9 to grade of Member

# OF CURRENT INTEREST

## Aircraft Navigational Instrument Gives Latitude and Longitude Automatically

An aircraft instrument that automatically gives a pilot his latitude and longitude without any air-to-ground or ground-to-air communication has been demonstrated by Ford Instrument Company, division of The Sperry Corporation. Already in production, the device promises to free pilots of most of their navigational problems. The full military name of the instrument is "The Computer Set, Latitude and Longitude *AN/ASN-6*," often referred to as a "Ground Position Indicator." It was developed by Ford Instrument Company under the auspices of the U. S. Air Force in conjunction with the Communications and Navigation Laboratory of the Wright Air Development Center.

The computer set weighs 45 pounds and is squeezed into a volume less than $1^1/_2$ cubic feet. The set consists of four boxes, the Indicator, Computer Control, Computer, and Amplifier.

Into the computer control the pilot dials his wind speed and direction, and magnetic variation. Into the indicator the pilot sets his take-off latitude and longitude. From the gyrocompass and air-speed indicator, which are standard equipment in airplanes, the computer receives true air-speed and magnetic heading. Once the plane is air-borne, the computer continuously calculates and the indicator continuously displays the airplane's changing latitude and longitude.

The indicator, shown in Fig. 1 without its case, is panel mounted. It receives the changes in latitude and longitude from the computer (see block diagram), by means of synchro transmission and continuously displays the present position in latitude and longitude on veeder-type counters. Two switches, one each operating a latitude and longitude slew motor, are attached to the front of the unit, and allow for the setting of the initial latitude and longitude of the aircraft at the place of departure, or in flight to any other known check point. This unit also is used to transmit by means of 2-speed synchro transmission to other dependent equipment the aircraft's present position in latitude and longitude.

The control-computer (Fig. 2) contains three knobs which are used to insert manually into the system wind force, wind direction, and magnetic variation data. The input data for the latter two quantities are read on coarse and vernier dials whereas the input for wind force is read on a counter. The control knobs also are connected to transmitters for conveying functions of the variables to the computer unit.

The computer (Fig. 3) contains the majority of mechanical and electromechanical computing elements. It receives by means of synchro transmission inputs of wind force, wind heading, and magnetic variation from the computer-control unit. It also receives electrical inputs of true air speed from a true air-speed computer, and magnetic heading from a slaved gyro magnetic compass. Within the computer unit is a cam-type compass-deviation compensator which corrects the magnetic heading input signal for transmission errors and residual compass deviation errors. With the input data it receives, the computer unit continuously calculates by means of resolving differential and integrating mechanisms, the changes of latitude and longitude, and electrically transmits these changes in latitude and longitude to the counters in the indicator unit.

The amplifier houses the power supply, time standard amplifier, and five servo amplifiers which service electric components

### Future Meetings of Other Societies

**American Institute of Chemical Engineers.** National Meeting. May 16–19, 1954, Kimball Hotel, Springfield, Mass.

**American Iron and Steel Institute.** 62d General Meeting. May 26–27, 1954, Waldorf-Astoria Hotel, New York, N. Y.

**American Welding Society.** National Spring Meeting. May 4–7, 1954, Hotel Statler, Buffalo, N. Y.

**Armed Forces Communications Association.** National Convention. May 7–9, 1954, Shoreham Hotel, Washington, D. C.

**Association of Iron and Steel Engineers.** Spring Conference. May 3–5, 1954, Belleview-Stratford Hotel, Philadelphia, Pa.

**Basic Materials Conference and Exposition.** May 17–20, 1954, International Amphitheatre, Chicago, Ill.

**California Society of Professional Engineers.** Annual Convention and Trade Show. May 27–29, 1954, Mark Hopkins Hotel, San Francisco, Calif.

**Edison Electric Institute.** 22d Annual Convention. June 1–3, 1954, Atlantic City, N. J.

**Electrochemical Society.** 105th Meeting. May 2–6, 1954, La Salle Hotel, Chicago, Ill.

**Electronic Parts Show.** May 17–20, 1954, Conrad Hilton Hotel, Chicago, Ill.

**Institute of Radio Engineers.** New England Radio Engineering Meeting. May 7–8, 1954, Sheraton Plaza Hotel, Boston, Mass.

**National Conference on Airborne Electronics.** May 10–12, 1954, Dayton Biltmore Hotel, Dayton, Ohio

**National Fire Protection Association.** 58th Annual Meeting. May 17–21, 1954, Hotel Statler, Washington, D. C.

**Operations Research Society.** 2d Annual Meeting. May 21–22, 1954, Edgewater Beach Hotel, Chicago, Ill.

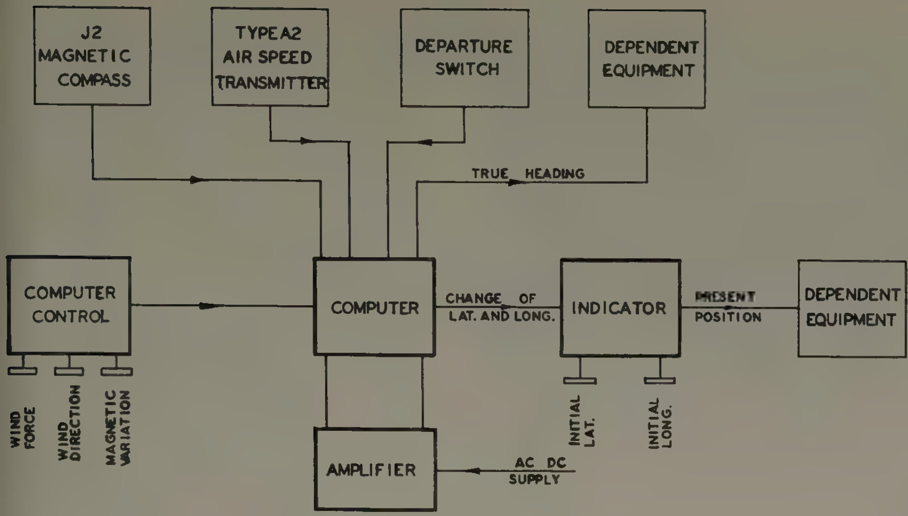
**Pacific Coast Electrical Associations.** Annual Convention. May 19–21, 1954, Hotel Del Coronado, Coronado, Calif.

**Pennsylvania Society of Professional Engineers.** Annual State Convention. May 7–8, 1954, Bedford Springs Hotel, Bedford, Pa.

**Radio-Electronics-Television Manufacturers Association.** 5th Government-Industry Conference. May 4-6, 1954. U. S. Department of Interior Auditorium, Washington, D. C.

**Society of Naval Architects and Marine Engineers.** Spring Meeting. May 17–18, 1954, Olympic Hotel, Seattle, Wash.

**Fig. 1 (left). Indicator is a panel-mounted unit on which present latitude and longitude are displayed continuously. The slew switches on the outer periphery are used to set in the initial latitude and longitude of the aircraft. Fig. 2 (center). Computer Control permits the pilot to insert the various manual inputs into the systems. The front or unsealed section of the computer control contains gearing, dial assemblies, and illuminating lamps. The sealed or rear section contains miniature synchro units and potentiometers. Fig. 3 (right). Computer of the electromechanical analogue type receives information of air speed, compass heading, wind force, and direction and continuously computes change in latitude and longitude**




**Block diagram of Computer Set, Latitude and Longitude AN/ASN-6**

in the computer unit. The power supply requires 115 volts, 400 cycles, single-phase, and 28 volts direct current from an aircraft supply in order to produce the B+, filament, and synchro power levels required by the system. The a-c load is approximately 230 volt-amperes at an 0.8 lagging power factor, and the d-c power required is approximately 11 watts. The power supply, and each amplifier, is an individual plug-in subassembly, and is easily removable for replacement purposes.

A portable and self-contained test panel is available with the computer set, which can be used to determine whether the equipment is functioning properly. If a malfunction does exist within the equipment, the test panel can simulate an actual flight condition by injecting one of the sample problems furnished with the test panel into the computer set. By comparing the results given by the system with the answers given with the problems at the appropriate check points, the malfunctioning of the equipment may be localized and serviced. The power required for the test panel is 115 volts, 400 cycles, at 25 volt-amperes.

For the military pilot the equipment is especially valuable since it does not need ground signals for its functioning. Nor does it send out signals, which an enemy could back-track to locate the airplane. In addition, the jet pilot is so occupied flying his airplane, searching the skies for enemy aircraft, and maneuvering to avoid anti-aircraft fire, that he has little time left for navigating.

The computer set can be valuable to the commercial pilot who would not have to depend on navigation by radio beam.

# Electrodes Coated With Powdered Metal Increase Welding Speeds 50 Per Cent

Heavily coated electrodes containing large quantities of powdered metal in their coatings obtain increased welding speeds on the order of 50 per cent, with appearance in smoothness and freedom from spatter almost equal to that obtained with automatic welding.

In general, as welding current increases, the speed of welding increases. The electric arc drawn from the end of a welding electrode performs the three functions of melting the core wire, melting the coating of the electrode, and melting the edges of the parts to be welded together. An increase in welding current increases the speed with which the arc can perform these functions. For any given size electrode, welding speeds can be increased until a maximum usable current is reached. Beyond this maximum current a further increase causes difficulties which result in unsatisfactory operation. The difficulty may be an overheated electrode causing a breakdown of the coating, it may be too much penetration, gouging of the parent metal, or too much spatter. In any case, the effect is to impose the top limit on welding speed.

Electrodes with powdered metal coatings are designed to raise this top limit on welding speeds by eliminating or reducing the effect of these difficulties.

The major cause of operating difficulties that limit welding speeds is the fact that the welding arc normally creates more heat than can be used effectively by conventional electrodes in melting the parent metal, the core wire, and the coating. This excess heat usually is expended in melting an excessive amount of parent metal. The arc force throws this excess and some of the melted core wire out of the molten pool. The result, depending on the application, may be too much penetration, gouging, undercutting, and spatter. The correction for the difficulty with conventional electrodes is to cut back on the amount of current used and slow up welding speeds until satisfactory operation is obtained.

Courtesy Lincoln Electric Company

**Horizontal fillet weld, plate size 3/8 inch, fillet size 5/16 inch, electrode size 1/4 inch. Current was 360 amperes, arc speed 14 inches per minute**

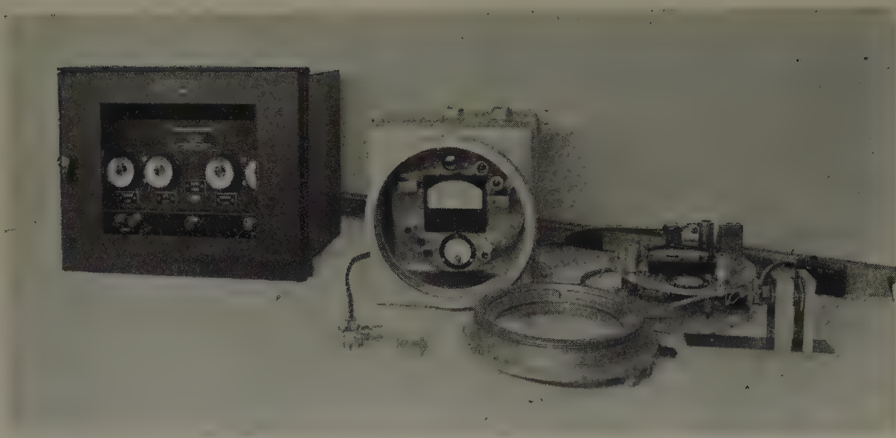
Electrodes with powdered metal coatings use the excess heat available in the arc to increase welding speeds. The powdered metal in the coating is melted by this heat and becomes an additional source of metal for the weld, thus permitting an increase in welding speeds. The difficulties of excess current, spatter, gouging, and undercutting are minimized and additional metal is available to make full welds at the higher speeds. If an electrode contains sufficient iron powder in the coating to supply one-third of the deposited metal from the coating and two-thirds from the core wire, that electrode can deposit metal 50 per cent faster than the same size electrode without iron powder in the coating. Proper balance is necessary between coating and core wire, for if too much iron powder is put into the coating, so much of the heat of the arc may be absorbed by melting the coating that there will not be enough to melt the parent metal and core wire.

In addition to reducing spatter, undercutting, and gouging, this more efficient use of arc heat by powdered metal coatings also reduces overheating in electrodes. Overheating is an operating difficulty frequently encountered on welding applications where the rate of metal deposition is the only controlling factor on welding speeds. The temptation is to push welding current up to its maximum since current controls the rate of metal deposition. The danger is that of overheating the electrode to a red-hot condition by forcing it to carry more current than its size warrants. A red-hot core wire will break down the electrode coating so that it cannot perform its functions satisfactorily. The limit to welding speed, therefore, becomes the maximum current which can be used without producing a red-hot core wire.

Powdered metal electrodes effectively raise the limit on welding speeds imposed by the current-carrying capacity of the core wire. More metal is available for deposition and the more efficient use of the arc heat permits increasing welding speeds without necessarily increasing currents.

## Noncontacting Distance Gauge Measures Shaft Displacement

A noncontacting distance gauge that measures the relative position of a high-speed rotating shaft has been developed by L. A. Marzetta of the National Bureau of Standards (NBS) at the request of the Department of Defense. The device employs a mutual inductance-type gauge



**Shaft displacement indicator developed at NBS. Cabinet at left contains power supplies and the alarm circuits. At center, the indicating unit and the exciter unit, mounted in an explosion-proof case for a special application. Transducer probe, in foreground, is the displacement sensing element for this instrument. At right, an exciter and indicator unit removed from its case**

to indicate the longitudinal movement of the shaft, such as might be caused by failure or wear of a thrust bearing. The equipment is designed to give continuous dependable service over a long period of time.

In the field of heavy rotating machinery such as steam turbines and internal combustion engines, it is sometimes desirable to monitor the relative position of some moving member. Turbines, in particular, having certain types of load are subject to rapid, unpredictable thrust bearing wear. Since the rotor and stator of a turbine are machined to close tolerances, excess longitudinal movement of the shaft presents the danger of interference of these parts and possible destruction of the machine. The NBS shaft position indicator detects and measures accurately the shaft displacement in either direction. When the displacement exceeds a prescribed limit, the indicator actuates an alarm, thereby warning operating personnel of imminent machine failure. Since the instrument also gives a direct indication of the amount of bearing wear, a bearing now may be used for its full useful life and need not be replaced very soon.

The detecting element in this system is a mutual inductance micrometer developed by M. L. Greenough of NBS. A transducer probe, consisting of two coaxial, coplanar coils wound on a dielectric core about 1/2 inch in diameter, is mounted on the turbine frame near the shaft. When the primary coil is energized from a regulated r-f source, a voltage is induced in the secondary coil. On the end of the turbine shaft is fastened a brass disk which forms part of the electrical system. Motion of the disk toward or away from the probe changes the mutual inductance between the two windings. Thus, the output voltage from the secondary is dependent on the spacing between the probe face and the brass disk. This voltage is indicated on a meter calibrated in thousandths of an inch and shows the shaft position relative to the main frame of the turbine. The probe assembly includes a graduated micrometer that provides for accurate adjustment of the spacing between the probe face and the disk.

Coupled to the micrometer probe is a 5-tube exciter unit which contains a regulated carrier oscillator to furnish current for the probe transducer, the detector circuit, and the meter for indicating the shaft position. In a separate chassis are the power supplies and the alarm circuits.

Although the instrument's function is to measure displacement of a rotating shaft in a longitudinal direction, it easily can be adapted to measure motion in the radial direction. Moreover, it can be applied to indicate the relative positions of oscillating, reciprocating, or quasi-stationary members over a wide range of displacements since the mutual inductance micrometer will measure lengths as small as 50 microinches or as large as several inches with an accuracy of 3 per cent.

# Circuit Ground Fault Detecting Method Utilizes Special Current Transformers

An indirect-couple method for detecting electrical faults—short or interrupted circuits—has been developed primarily for aircraft systems. Also, the new detection method can be incorporated into industrial circuits to insure against the fire hazard of electrical faults.

One of the most unique design aspects of the circuit is the fact that current transformers are used. General belief holds that transformers in d-c control circuits are impractical. Actually, the transformer used in this circuit is a special design featuring a very large air gap (0.075 inch). This air gap is easy to hold in production and, therefore, can be termed noncritical. The air gap in the transformer's magnetic path makes possible a large turns ratio for indirect coupling to the sensing circuit. This large turns ratio gives a very high degree of sensitivity to current rate changes. Whereas conventional transformers reach saturation rather early and would be impractical for this type of control use, the special transformer of Jack and Heintz, Inc., exhibits a linear response characteristic throughout the load range.

Briefly, the detecting circuits are hooked up and operate as follows:

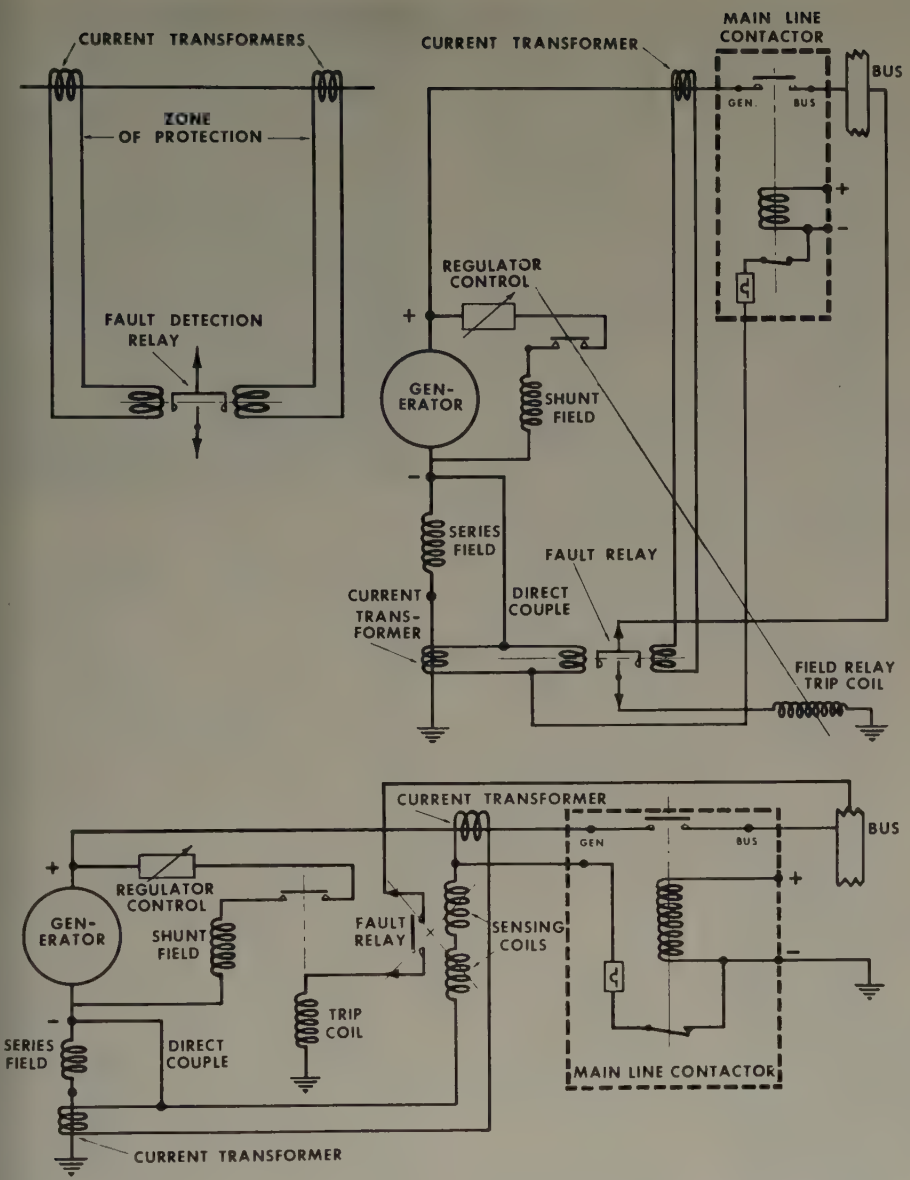
*Indirect-Couple:* The indirect-couple circuit involves two current transformers located electrically to include a maximum zone of fault protection to the feeder cables and the generator. The feeder cables are passed through the opening in the core of the current transformers (effecting the indirect couple). In this manner, the feeder cable becomes the primary winding of the current transformer. Because of the indirect couple between the primary and secondary, the current in the transformer secondary is dependent upon the rate of change in the primary (feeder cable). Each of the current transformer secondaries is connected into either single- or dual-comparison circuits which include a fault detection relay. Operation of this relay, which serves to trip off the generator in the event of fault, depends on a differential between the signals developed on the transformer secondary windings. Basically, therefore, the detection of a ground fault in the protection zone between the transformers depends upon a differential in the rate of current change in the current transformer primaries (feeder cables).

*Direct-Couple:* To insure that faults present during generator build-up are detected, a direct coupling is made from the negative brush of the generator to one side of the fault detection circuit and from the other side to the ground. This circuit will detect any voltage build-up on the generator interpole and compensating windings and signal the fault relay to close its contacts. A set of normally closed contacts open and close the directly coupled circuit as required. During generator build-up when the electric system is disconnected from a bus by a main line contactor, the directly coupled circuit is completed by an auxiliary set of main-line contactor contacts and detects any faults. During the period when the main contactor is closed, the directly coupled circuit is open and the indirectly coupled circuit will detect a ground fault.

*General Design and Layout Data:* The current transformers and the fault-detection relay are designed with specific resistance and inductance relative to each other, such that ground faults which produce various rates of current build-up can be detected. This combination of impedance matching provides an optimum value in sensitivity to detect all fault currents under normal operating conditions.

The actual operation of the fault relay itself upon the receipt of the signal from either the directly or indirectly coupled circuits is as follows: When the contact arm closes the circuit upon actuation by either or both coils in the fault-detecting relay, the field trip coil is energized and the normally closed relay contacts in the shunt-field circuit of the generator will open to break the shunt field, thereby de-energizing the generator.

The fault-detection circuit requires the use of a nonpolarized relay. Certain types of




**Circuit diagrams of current transformer method of fault detection. (Above) Current transformers and relay showing zone of protection. (Right) Circuit with two series loops. (Below) Circuit with a single series loop**

ground faults cause the fault current to build up on a positive direction again. This type of fault may result from an intermittent contact of a cable with a grounded section. The nonpolarized relay is necessary to detect and remove this type fault because it is insensible to the change in polarity. In comparison, it may be stated that the polarized-type fault-detection relay will sense the change in direction of the fault current and chatter during this type fault.

The method of fault detection just described can take two circuit forms:

*Two Series Loops:* In this circuit, the two current transformers are connected in two separate series loops and the relay coils are connected opposing. With the application of loads and other switching transients equal signals are imposed on the two relay coils and this results in zero magnetic force on the relay armature. The directly coupled circuit from the generator terminal to the ground through the main contactor signals one coil when a fault is present during generator build-up.

This circuit will result in a system trip when a sensing cable opens or short-circuits. This circuit is recommended for use in multi-generator aircraft or industrial circuits where the removal of one generator will not create an emergency.

*Single Series Loop:* In this circuit, two current transformer secondaries and both relay coils are in one series loop. The current transformers are connected to oppose each other during load application and removal. Because equal opposing signals are present, there is no current flow in the series loop. When a ground fault occurs, a signal is impressed on only one of the current transformer secondaries. This causes a current flow in the series loop which energizes the two relay coils connected series aided. The directly coupled circuit from the generator terminal to ground through the main contactor signals the two relay coils in series when a fault is present during generator build-up.

This circuit will not result in a system trip when sensing cables open or short-circuit.

The single series loop circuit is recommended for use on single- and perhaps dual-generator systems where the removal of a generating unit may cause an emergency.

## Powerful Air-Borne Search Radar Being Installed in Aircraft

The General Electric Company is producing the most powerful air-borne search radar yet developed, under a multimillion dollar contract with the U. S. Navy's Bureau of Aeronautics.

The new radar is about twice as powerful as any previous air-borne search unit. The powerful radar is being installed in a number of Navy and Air Force aircraft, including new flying radar stations being built by Lockheed Aircraft Corporation, patterned on the Super Constellation transport.

The Navy will use the high-altitude 4-engine airplanes as radar stations to fly off the Atlantic and Pacific coasts. The planes will fly from shore bases, and are capable of patrolling for long periods far at sea.

The Air Force will utilize the flying radar stations to supplement its land-based "radar fence," now guarding the United States and Canada against sneak enemy air attack. The high-flying radar stations greatly will extend the detection range of the "radar fence," whose land-based radar beams do not bend over the horizon.

Information from the radar in each plane is presented on the radar scopes according to the requirements of the operators. Special provisions in the indicator system permit the radar's use for antisubmarine, aerological weather reconnaissance, and navigational purposes in addition to aircraft detection.

Normally, each operator concentrates on a

**Antenna test site for most powerful air-borne radar, being built by General Electric at Utica, N. Y., for the U.S. Navy, simulates installation in the aircraft, where radar antenna will be housed in a radome below the fuselage. The radar is for use in high-altitude long-range flying radar stations**

particular segment of the radar screen before him.

The two radar antennas are housed in radomes, atop and below the aircraft's fuselage.

The flying radar stations will carry about 6 tons of electronic equipment. The search radar and indicator system weigh about 2 tons.

The weight and size of the new radar and indicator systems have been kept down, despite the increased power, by the use of printed circuit techniques in manufacturing. Nearly all electronic chassis are printed wiring subassemblies, which are easily maintained, and replaced individually, if necessary.

The new, more powerful radar is a vastly improved successor to an air-borne search radar jointly developed by the Massachusetts Institute of Technology and General Electric shortly before the end of World War II.

## IRE Honors Goldsmith, Everitt at Annual Convention in March

Dr. Alfred N. Goldsmith (F '20) and Dr. William L. Everitt (F '36) were honored at the annual banquet of the Institute of Radio Engineers (IRE) held during the Institute's annual convention in New York, N. Y., March 22–25, 1954. Dr. Goldsmith, who became editor emeritus of the *Proceedings of the IRE* after 41 years as editor, was presented with the IRE Founders Award. This award is bestowed only on special occasions for outstanding leadership and administration of important technical developments. Dr. Everitt, dean of the College of Engineering, University of Illinois, was awarded the IRE Medal of Honor, given annually in recognition of outstanding scientific and engineering developments.

The Founders Award was presented by J. W. McRae (M '50), IRE past president. IRE President W. R. Hewlett (M '47) presented the award to Dr. Everitt. Other 1954 award winners were Dr. R. R. Warnecke, the Morris Liebmann Memorial Prize Award; Dr. R. L. Petriz, the Browder J. Thompson Memorial Prize Award; P. W. Howells, the Editor's Award; Dr. Harold A. Zahl, the Harry Diamond Memorial Award; and A. V. Bedford, the Vladimir K. Zworykin Television Prize Award. Seventy-six members were elevated to the grade of fellow.

Dr. Goldsmith, speaking on the "IRE—Past and Future," described the growth of the Institute and mentioned some of the fields in which electronics was bringing great advances.

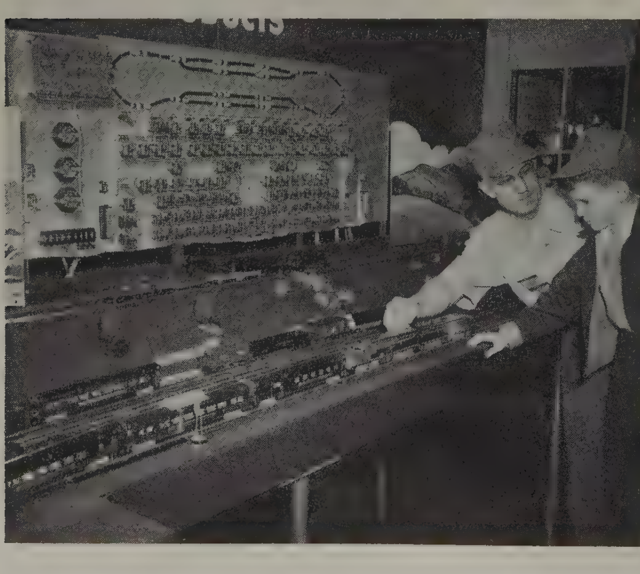
During the 4 days of the annual convention over 40,000 engineers attended the radio engineering show and the technical sessions. There were over 600 exhibits at the show, comprising electronic equipment ranging from transistors to complete broadcasting stations.

At the technical sessions advances in medical electronics, transistors, audio, and color television were described. A system for taking color X-ray photographs was reported. The use of color X rays is based on the fact that different materials absorb X rays differently, the differences in absorption being converted into visible colors.

A radio using only transistors was described, as well as the problems of designing such a tubeless radio. Because of their tiny size, low power consumption, and long life, transistors are particularly suitable for use in personal portable radios. The next step appears to be the wrist-watch radio.

Automatic air traffic control systems, stereoscopic radar, flight directors, and a new gyroscopic compass independent of the earth's magnetic field also were revealed.

Other sessions ranged from discussions on information theory to how to attain good musical reproduction. A total of 243 papers were discussed in the 51 technical sessions.

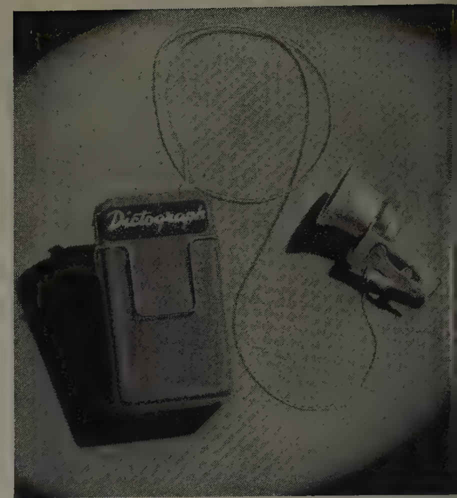


Model train system displayed by General Electric at IRE convention demonstrates how germanium products can be used in power, switching, and blocking circuits. Some 1,400 feet of wire, 96 relays, and about 200 germanium diodes and power rectifiers were used in the automatic control system

## Transistors Used in Receivers of Personnel Paging System

A new personnel paging and communication system with portable receivers smaller than a cigarette package has been demonstrated by Dictograph Products.

Utilizing the transistor, the new communication system makes possible the paging and relaying of messages to certain key preselected personnel. These messages are transmitted only to those so designated. There is no public address, no blaring, or disturbing horns. In hospitals, for example,




Miniature receiver can be carried in pocket and lapel speaker clipped on for portable private personnel paging

physicians and nurses can be paged without disturbing patients.

The system is particularly adaptable for use in offices, hospitals, department stores, ships-at-sea, freight yards, manufacturing plants, banks, sporting arenas, and theaters.

Each of the key personnel is equipped with a lightweight receiver and a midget "speaker." The total weight of the transistorized receiver and the speaker is under 4 ounces. These speakers permit only the wearer to pick up the message, and operate on a true tone fidelity.

Perfected a short time ago, the first system was installed in mid-January 1954 at the Orlando (Fla.) Air Force Base Hospital. Here it was put through a series of shake-down tests to determine its fitness for use by the Army, Navy, and Air Corps. The system was installed in an area covering six wards and the walk-ways of the hospital. The results were excellent, and among the observations made was this: With former blaring, horn-type loudspeakers the average time to locate key personnel ranged from 4 to 9 minutes. With Miracle Page, personnel were located within 15 seconds.

Another feature of the system is the fact that it will permit receipt of messages in an area of high noise level. With conventional loudspeaker paging systems, if a high noise level can be overcome, it must be accomplished with horns blaring at an even higher noise level. With Dictograph Miracle Page, however, due to the proximity of the sensitive speaker to the wearer's ear, messages can be delivered and received at a normal decibel level.

Another important feature is the fact that transmission is confined to a specific area. The system covers an area 40 by 1,000 feet. The distance can be extended to 2,000 feet if loops are interconnected.

The highly sensitive receiver unit, composed of three transistors and an induction loop, is housed in a moisture-proof case of modern design. It includes a volume control, variable adjuster mechanism, and a flexible cord. A high-fidelity flat-response receiver, modulated for 250 to 5,000 cycles, coupled to a unique acoustical bell-horn, assures full sound reception.

Each unit is equipped with a self-contained long-life mercury battery in a specially

insulated container for easy replacement. The system is made to utilize any standard amplifier designed for paging in which the amplifier is connected to an impedance-matching transformer which connects the amplifier to the induction loop.

The system functions vertically as well as horizontally. In an installation in a 6-story building, for example, the induction loop would be located near the ceiling of the third floor. Personnel could be paged on any floor above or below the loop.

The dimensions are: $1^3/_4$ inches wide by $3^1/_8$ inches long by 13/16 inch thick. No radiation of message reaches beyond the confines of the specific area of installation.

## Punched Card Transmitter "Talks" Over Telephone Circuits

Development of the first punched card transmitter that "talks" over regular telephone circuits at the rate of almost 1,000 alphabetic or numeric characters a minute was announced here today by International Business Machines Corporation (IBM). Also capable of checking the accuracy of its rapid-fire "conversations" by listening in on them, this new development insures the exact, fast duplication of punched card data between points thousands of miles apart.

Utilizing the widespread telephone and telegraph networks to link these new card transmitting and receiving units, this machine now makes possible the swift transmission of accounting data from decentralized branch office and plant locations to any central point such as a company headquarters. Known as the IBM Transceiver, the same unit is used for transmitting and receiving on a fully automatic basis.

The Transceiver, for the first time, provides a transmission method employing normal telephone circuits for remote punching of cards and has been designed with checking features capable of meeting the critical standards of accuracy.

When information is to be sent to a distant point, the Transceiver reads the data recorded in IBM cards in the form of punched holes. As the cards are being read, electronic circuits generate coded impulses in the form of "beeps," each series of sounds representing a hole in the card. These sound signals actuate the punching mechanism in the distant receiver which simultaneously creates exact duplicates of the cards being transmitted. The newly created punched cards then become immediately available for accounting machine and computer processing.

Each hole transmitted is checked automatically, and after each card is completed the transmitter sends a signal which checks on the accuracy of the data reproduced by the receiver. This signal will "echo" back if the card has been punched correctly and cause the transmitter to proceed automatically with the next card.

When the machines are linked by telephone lines, 16 card columns of data can be transmitted and received every second and 4 separate transmittals can be sent simultaneously over the same wire. When linked by telegraph lines, over which one transmission at a time can take place, the transmitting speed is 6 columns a second.

## Low-Cost Digital Computer for Engineering Use Unveiled

Wider use of electronic computers in science and industry was seen with the announcement of successful development by Logistics Research, Inc., Redondo Beach, Calif., of ALWAC, a new low-cost, reliable general-purpose electronic digital computer.

The new electronic brain is said by its developers to do the work of a million-dollar machine yet costs only 5 per cent as much. According to Logistic's president, Glenn E. Hagen, ALWAC provides increased reliability and cost savings, never before realized with previous machines. Its internal memory system is the most efficient of any low-cost general-purpose computer ever developed.

Technically ALWAC is a serial, binary computer with internally programmed magnetic drum. The machine consists of an arithmetic unit, memory unit, control unit, and input-output sections.

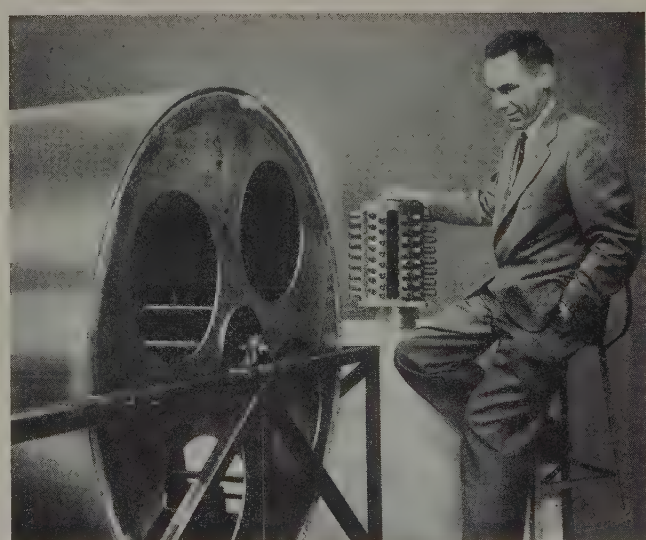
ALWAC features a large-capacity rotating magnetic drum memory of 2,048-word main storage capacity which stores the numbers and instructions used by the machine to perform its computations. All of the units of the machine make use of information stored on the surface of this drum. The drum is composed of a cylinder rotating about its longitudinal axis, with a number of reading and writing heads mounted in near-contact with the surface of the cylinder. A given head serves both as a reading and writing device.

Basic commands are put into the machine and answers obtained from it, on electric typewriters and paper tape perforating and tape reading equipment. As many as ten electric typewriters can be attached to the machine at various remote locations.

Numbers to be entered in the computer normally are typed on the electric typewriter in decimal form with decimal point and sign. Alphabetic information also can be handled. A visual copy is typed at the same time, which may be compared immediately with the coding sheet for typing errors. The information then is transferred automatically to magnetic drum storage by the tape reader. Information also can be entered manually directly from the typewriter keyboard. Conversion from decimal-to-binary and binary-to-decimal is performed automatically at approximately the maximum rate of the electric typewriter reading and writing speed of ten operations per second.

Automatic graph-following and graph-plotting equipment also can be provided as input and output equipment for this computer. One version of the automatic graph follower will handle a function of two variables. Families of curves on a single sheet may be used and the follower will switch automatically from one curve to another in response to commands from the computer

**Electric typewriter is used to put basic commands into ALWAC and to obtain answers from it. Control panel at operator's left detects coding or machine errors, stops the computer, and lights up to show where the operator has made an error**



**Air-floating 4-foot metal drum uses a new principle of computer memory. Memory capacity of new drum is 200 times greater than the conventional magnetic drum at left**

and automatically transmit the reading to the computer's memory.

To the direction of internal programming the arithmetic unit performs the four arithmetic operations of add, subtract, multiply, and divide. Forty-two variations of these basic operations are included in possible commands. A remote control panel permits the operator to change manually previous instructions in accordance with the progress of the problem.

The control unit controls the activities of the machine. It receives command words from the memory, and receives other signals from the arithmetic unit. It combines this information and transmits the proper impulses to the arithmetic, memory, and input-output units so that they perform the operations specified in the commands. The unit includes the command register, which holds the instructions which control the machine at any given time, and the control register to which the instruction is transferred when it is actually controlling the machine. A "next command register" contains the next instruction to the machine.

## CAA Approves New Aircraft Selective Calling Equipment

The Communications and Electronics Division of Motorola, Inc., has announced Civil Aeronautics Authority (CAA) approval of its newly developed tone-coded selective signaling system called Airborne "Quik-Call." It is reportedly the first of its type to receive CAA-type certification. Known generically in the aircraft industry as SELCAL, this equipment allows ground-to-air radio transmissions to preselected individual aircraft, functionally similar to a conventional telephone system.

Such an alerting system relieves the pilot or radio operator of the responsibility of maintaining a continuous listening watch on the aircraft's radio channels and completely eliminates the effects of nuisance noise. Constant radio monitoring heretofore has contributed substantially to pilot fatigue and an insensitivity to messages as time elapses or a disregard of the radio receiver because of other attention-requiring factors. These factors are safety hazards overcome by the new selective signaling system. The Quik-Call device does not disrupt normal receiver reception, but allows the headset to be removed or loudspeaker to be switched off until a call signal is received.

Each aircraft is equipped with a selective signaling decoder for each radio channel which must be monitored for an alerting signal. The ground-located base station transmitting to aircraft is equipped with a tone code selector and code generating unit. To call a specific airplane, a tone code is selected and transmitted by the dispatcher. Upon reception, this tone code activates a light or bell notifying the air-borne radio operator that a call is intended for him. Only the selected aircraft is alerted. Receiver alarms in other Quik-Call equipped aircraft do not respond even though tuned to the same radio frequency. Nonequipped receivers monitoring the channel hear only an instantaneous tone pulse.

The new SELCAL equipment operates on the same principle as the Motorola Quik-Call system of tone code transmission which has been used in land-mobile 2-way radio systems for more than 7 years. Airborne Quik-Call has been under development for almost 2 years and for the past year has been subjected to more than 500 hours of strenuous flight condition testing and simulated operation on Pan American World Airways Pacific air routes.

Vibrasenders, extremely stable mechanical oscillators (or tuning forks), control the frequency of the electronic tone-generating circuits. When the button on the selector panel is pressed, two coded pulses, each containing two discrete tones, are transmitted sequentially. These tones, received in the aircraft's receiver, are fed to a decoder unit containing companion Vibrasponders, essentially resonant reed relays, which respond only to specific tones. Upon receipt of the proper tone combination, a relay is energized to actuate either an audible or visible alert alarm.

A total of over 1,400 individual codes can be created from 12 basic tones without duplication or without tone combinations conducive to false operation.

The air-borne unit is packaged in a shock-mount housing. The Model *TA-150* (*CAATC-3R39–1*) which is a 2-channel decoder, weighs slightly less than 13 pounds. A single-channel decoder, Model *TA-151* (*CAATC-3R39-2*), also is available.


**Pan American World Airways dispatcher in Auckland, New Zealand, presses button on Airborne Quik-Call tone selector panel**

## Dr. Thorndike Saville Elected President of EJC

Dr. Thorndike Saville, dean of the College of Engineering at New York University, has been elected president of the Engineers Joint Council (EJC) for 1954. The Council co-ordinates activity in the engineering profession and represents the 170,000 members of its eight constituent societies.

Elected vice-president of the Council was Carlton S. Proctor, president of the consulting firm of Moran, Proctor, Mueser and Rutledge, and past president of the American Society of Civil Engineers.

Dean of New York University's engineering college since 1936, Dr. Saville is a past president of the American Society for Engineering Education and past director of the American Society of Civil Engineers. He is a member of the U.S. Beach Erosion Board and engineer member of the New York State Public Health Council.

An authority on hydrology, water supply, and coastal engineering, Dean Saville has served on various boards and commissions and as consulting engineer on projects in his field. He was chairman of the Engineering Panel on Future Water Supply for New York City; executive engineer, Water Resources Section of the National Resources Board; consulting engineer for the Rockefeller Foundation to the Government of Venezuela; and advisor to the Public Works Committee of the first Hoover Commission.

The new executive committee consists of Dean Saville, Mr. Proctor, and the following engineering society representatives: W. M. Peirce, American Institute of Mining and Metallurgical Engineers; F. S. Blackall, Jr., The American Society of Mechanical Engineers; C. H. Capen, American Water Works Association; W. J. Barrett, AIEE; L. R. Sanford, The Society of Naval Architects and Marine Engineers; and C. G. Kirkbride, American Institute of Chemical Engineers.

## Program in Automatic Control of Machine Tools Planned

Plans for a 2-week special summer program in the Automatic Control of Machine Tools, to be held from August 23 to September 3, 1954, in the Servomechanisms Laboratory at the Massachusetts Institute of Technology (MIT), were announced recently by Professor Ernest H. Huntress, director of the MIT Summer Session.

Though this subject was not originally planned for the 1954 Summer Session, Professor Huntress points out, "insistent demand" for technical information on the rapid recent development of this field prompts a last-minute addition to MIT's summer offerings. The program will be under the direction of Professor J. Francis Reintjes, director of the MIT Servomechanisms Laboratory in the Department of Electrical Engineering, who will be assisted by other members of the laboratory staff.

Morning sessions of the 2-week program, according to Professor Reintjes, will be devoted to studies of systems and components including the following topics: principles of information processing as applied to the

use of machine tools; numerical control systems and their machine tool applications; equipment design for numerical control systems, including data input and storage devices, computational equipment, servomechanisms for machine tool control, etc.; design considerations for system reliability; and management, operation, and maintenance of numerically controlled machine tools.

In addition, there will be less formal afternoon sessions devoted to programming techniques, using the numerically controlled milling machine developed in the Servomechanisms Laboratory under U. S. Air Force sponsorship. Topics in these sessions will include the mathematics of programming, practical procedures, and machine aids.

This special summer program in Numerical Control of Machine Tools, Professor Huntress pointed out, is directed toward those who want a broad view of the technical aspects of numerical control as they apply to machine tools. "It should be especially significant," he believes, "to engineers contemplating the application and use of such equipment and therefore desiring direct experience with machine programming and use."

Professor Huntress stressed that, since the number of registrants necessarily must be limited, preference will be given to applications from those who now are engaged in designing or applying automatic machine tool equipment or who anticipate entering this field. Tuition for the program will be $160.

This special summer program in Automatic Control of Machine Tools supplements a 2-week program in Machine Tool Technology to be given in the MIT Mechanical Engineering Department from June 15 through June 25, 1954. Further information and application blanks for either program may be obtained from the Summer Session Office, Room 7-103, MIT, Cambridge 39, Mass.

## Light-Sensitive Switch Combines Stable Performance, Low Cost

**The Lumatrol switch shown with its diffusing cover molded from Plexiglas V-100 molding powder. Height and diameter are only 5 and 4 inches, respectively**

A light and compact light-sensitive switch now in production for individual control of street lights and outdoor lamps promises improved reliability and sharply reduced cost for utilities, municipalities, industrial plants, airports, and other users.

Called the Lumatrol switch, it was developed to meet the growing trend toward individual control based on the marked savings possible with the elimination of leased control-wire circuits. Individual switches also can compensate for local conditions such as deep shade. Further, this individual control adjusts automatically for current interruptions and seasonal changes in daylight hours which compel frequent resetting of time clocks.

The Lumatrol switch derives its principal advantages from its simple electronic circuitry and from the properties of a diffusing cover molded of water-resistant Plexiglas acrylic plastic.

Only 5 inches high and 4 inches in diameter and weighing but 20 ounces over-all, this switch is controlled by a *GL-929* light-sensitive tube. When light of values as low as 1/2 foot-candle falls on the unit, this tube (adjustable by a lockable potentiometer) triggers a grid-controlled rectifier tube whose output, about 3/4 watt, heats a small resistance element wound on a bimetallic strip. Bent by this heating, the strip makes contact with a pin-type micro switch.

An unusual design isolates this train of events from any influence by ambient temperature, which may range from below zero to above 100 F. A second and identical bimetallic strip without a resistance element is mounted parallel with the first, and the two are riveted to opposite sides of a pivoted ceramic base. Distance between the two remains contant under variations in ambient temperature, so that changes in temperature will not cause the micro switch to operate. When daylight causes current to reach the resistance element, however, only the strip on which the element is mounted is bent; the distance between that strip and the compensating strip increases and the switch pin is depressed, opening the circuit and shutting off the lamp.

Because two full minutes are required for the bimetallic strip to heat or cool enough to make or break contact, the device is not affected by transient light from car headlights or a mischievously wielded flashlight.

For shielding the switch, engineers at Micro Balancing Inc., manufacturer of the Lumatrol unit, first experimented with an aluminum cover in which a cutout window admitted light to the light-sensitive tube. This proved too directional, and in some installations exposed the tube to direct sunlight, causing excessive emission and shortening the tube's useful life. Glass covers also proved unsatisfactory because of breakage and the presence of sharp reflectances.

Further research led the manufacturer to standardize on an acrylic plastic cover which is molded from clear Plexiglas molding powder of the *V-100*, heat-resistant grade, then sand-blasted on the interior surface to combine the desired degree of diffusion with the high light-transmitting property of the plastic. This diffusion allows the tube to sense light from any direction, although in each installation the tube is oriented to the north, to minimize exposure to direct sunlight, with the aid of a legend printed on the cover. Use of the heat-resistant molding powder permits the covers to withstand exposure to heating at 180 F.

Installation of the assembled switch is by simple plugging of a 3-pronged twist lock into an adapter socket easily mounted on top of a standard street lamp fixture or attached by bracket to the pole or a nearby wall.

## Most Powerful Accelerator Goes Into Successful Operation

The world's most powerful particle accelerator, the University of California Bevatron, has gone into successful operation. The machine has accelerated protons, the nuclei of hydrogen atoms, to an energy of 5 billion electron volts (BEV), the highest energy ever achieved by an accelerator.

The Bevatron went into operation approximately 6 years after its design first was conceived and 4 years after construction began. The $9 million machine was built with Atomic Energy Commission (AEC) funds.

Lewis L. Strauss, chairman of the AEC, said the operation of the machine constitutes another step forward in the AEC's program to keep America in the forefront of atomic progress.

"Nuclear progress is not simply a matter of building power plants and weapons with present knowledge," Mr. Strauss said. "It is even more a matter of learning, for future use, what we do not yet know about the atom. For, just as we ushered in the atomic age with the knowledge that had been obtained years before, so tomorrow's practical nuclear developments for the support of freedom and peace will arise from the foundations of knowledge we build today."

Dr. Ernest O. Lawrence, director of the University of California Radiation Laboratory (UCRL), said:

"Although we have extracted energy from the atom, we are still far from an understanding of the forces and processes that govern the atomic nucleus.

"The Bevatron gives us the means to make laboratory explorations of the nucleus that have not been possible before. We do not know what we shall find, for if we did there would be no need to build the machine. We do know that every time we have extended the energy range of nuclear research, we have increased our understanding of the

fundamental nature of the atomic nucleus.

"During the last 4 years we have worked closely with the Brookhaven National Laboratory. The successful operation of their Cosmotron accelerated the early operation of our Bevatron."

All of the components of the Bevatron were tested separately prior to February 2, 1954. On that night the crew of physicists, engineers, and technicians began the effort to make all of the components work together.

The first major problem was to perfect the injection of protons into the Bevatron accelerating chamber. This involved making two satellite accelerators work together to get protons up to high enough energy to be handled in the big machine.

After injection was achieved, the physicists developed the giant magnet's control of the particles in the accelerating chamber. The protons were allowed to coast around the chamber while control was tested.

Finally, the oscillator, which boosts the protons to high energy, was turned on for acceleration to high energy. First successful acceleration was achieved February 15, 1954, when the protons reached 20 million electron volts. The energy was built up gradually until 4.7 BEV was reached on the evening of March 9, 1954. UCRL physicists now are working to push the machine to its design energy of 6.25 BEV.

The beam is detected by means of a scintillation counter placed on the end of a lucite rod, or probe, stuck into the accelerating chamber. When protons in the beam strike the counter, the collision causes a flash, which is converted into a signal that can be read on an oscilloscope.

Experiments with the Bevatron now are being planned, and will begin soon. Meanwhile, the physicists are working to build up the energy and intensity (number of particles) of the beam, and to achieve reliable operation.

The following is a brief summary of the operation of the machine.

Protons from an ion source, are accelerated in a Cockroft-Walton generator to 500,000 electron volts. The protons' energy is increased to 10 million electron volts (MEV) in a linear accelerator. By means of an "inflector," the beam is brought into the accelerating chamber of the Bevatron at such an angle that the particles are caught by the magnetic field.

The particles circle the accelerating chamber some 4,000,000 times, traveling about 300,000 miles. During this journey the particles are guided by the magnetic field over a precise orbit. As the particles gain energy, the increasingly strong magnetic field forces them to remain in this prescribed orbit.

The particles receive an average of about 1,300 volts of energy on each trip around the chamber. The frequency of the oscillator (pushes) is increased to compensate for the increasing speed of the particles, which finally attain a speed approximately 99.2 per cent of the speed of light.

Thus the machine incorporates both frequency modulation and variation of the magnetic field.

The protons emerge from the Bevatron at an energy of 6.25 BEV. At this energy, the particles are cosmic rays of the medium energy range. Twenty pulses of protons a minute, each containing about 100 million of these particles, emerge from the machine.

The beam of protons knocks neutrons and protons out of atoms. It generates showers of mesons and other synthetic secondary cosmic-ray particles.

These cosmic-ray events are detected and studied by means of counters, photographic emulsions, and cloud chambers.

## AEC and Duquesne Light Company Negotiate on Atomic Power Plant

Lewis L. Strauss, chairman of the Atomic Energy Commission (AEC), has announced that a proposal submitted for participation by the Duquesne Light Company of Pittsburgh, Pa., in the construction and operation of the nation's first full-scale central station nuclear power plant is the most favorable to the Government and that the AEC is negotiating a formal agreement with the company. The Duquesne Light Company submitted one of nine major proposals to the Commission.

Under the Duquesne proposal the company would

1. Furnish a site for the entire project and build and operate a new electric generating plant at no cost to the Government.
2. Operate the reactor part of the plant and bear the labor costs thus entailed.
3. Assume \$5 million of the cost of research, development, and construction of the reactor portion of the plant.
4. Pay the Commission at the rate of 48.3 cents per million Btu's of steam used in the turbines for the first year; the rate increasing annually until it reaches 60.3 cents in the fifth year.
5. Waive any reimbursements by the Government of cost incident to termination of the contract.

The chairman estimated that, including revenues from the sale of steam generated by the reactor, the company's proposal would reduce by an estimated \$30 million the expenditures the Government would have to make during the period of construction and 5 years of operations if it undertook the full cost of the project.

The proposed plant site is on land presently owned by the company in the Greater Pittsburgh area. The reactor design will incorporate safety features developed through 10 years of experience with reactor operation.

The Westinghouse Electric Corporation has a contract with the AEC to develop, design, and construct the reactor portion of the plant. The reactor is expected to generate sufficient heat to produce a minimum of 60,000 kw of salable electricity in addition to meeting the electricity requirements of the plant itself. The actual capacity of the reactor may turn out to be somewhat greater than the minimum of 60,000-kw design and foreseeing this possibility the company would design its generating plant with some reserve capacity.

It is not expected that this first plant will produce electric power at cost competitive with power from conventional fuels. The project has been undertaken in order to gain more design and technological experience than could be obtained otherwise, such as from a smaller plant, and to provide firm cost estimates for the future.

This type of reactor, known as the Pressurized Water Reactor, will be cooled and moderated by ordinary water under pressure. The fuel will be slightly enriched uranium, that is, it will have a slightly greater concentration of uranium 235 than occurs in nature. This type of reactor was selected because research and development on it is more advanced than on other types. Several early reactors were water cooled and this technology also was advanced to a very great extent by the work of Westinghouse on the Submarine Thermal Reactor developed to power the submarine *Nautilus* and on the large naval vessel reactor project.

## Zone-Melting Process Provides Method for Refining Germanium

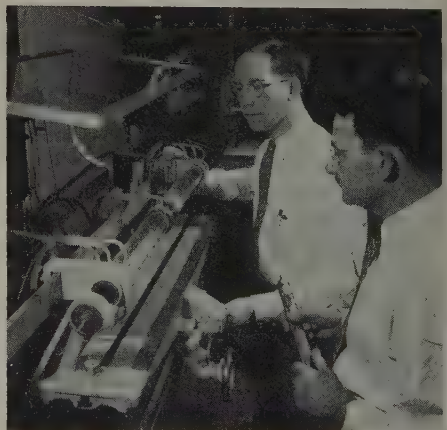
A new and extremely simple method for refining germanium and other materials to practically perfect purity—99.99999999 per cent pure—has been developed at Bell Telephone Laboratories.

A substance this pure very well may be the purest material in existence, for it has only one atom of impurity in ten billion atoms of the material. This is about the same as a pinch of salt in 35 freight cars of sugar.

The new process is already in use in the purification of germanium for transistors. Zone-melting, as the new purification process is known, was invented by W. G. Pfann, a member of the technical staff of Bell Laboratories.

It also is being used to refine a wide variety of materials other than germanium—metals, other semiconductors, and various organic and inorganic substances. Extremely pure tin and antimony, for example, have been prepared by the new process and metallurgists believe many other ultrapure metallic materials should be available soon.

The new process is based on the fact that impurities are not equally soluble in the solid and liquid states of a substance; usually,



**W. G. Pfann, left, inventor of zone-melting process, is shown operating the refining equipment, while J. H. Scaff, also associated with the development, holds a large single crystal of germanium purified by this technique**

impurities are more soluble in the liquid. To take advantage of this, a narrow molten zone is moved slowly along an ingot of relatively impure material to "sweep" the impurities to one end of the ingot.

This is accomplished by passing the ingot through a circular induction heater which, in the case of germanium, brings it to the molten state at a temperature of about 1,760 F. As the ingot is passed slowly through the heater, the molten zone tends to hold the impurities while the ingot solidifies into a purer state on the other side of the heater.

In actual practice, a series of such circular heaters is used and each molten zone extracts its share of impurities from that left by the preceding zone. At the end of the run, substantially all the impurities have been "swept" to one end of the ingot. Here they are trapped when the tip of the ingot passes out of the heater and solidifies. This section, loaded with the impurities swept into it from the entire ingot, then may be cut off.

The behavior of germanium in transistors is affected critically by the presence of impurities in the germanium but the kind and amount of impurities must be rigidly controlled for efficient operation. This is accomplished by refining an ingot of germanium to a near-perfect state of purity by the zone-melting process. Then its electrical properties can be altered to the desired degree by the controlled addition of such impurities as arsenic and antimony.

The zone-melting technique, adapted to the requirements of production operation, is now used to make the ultrapure germanium required in the manufacture of transistors.

The sweeping action of the zone-melting process serves a dual purpose. In addition to obtaining the utmost in purification, the process also permits the identification of impurities which may be present in such minute amounts that they defy positive detection by all available analytical tools. Once the impurities are concentrated at one end of the ingot, however, they are much more easily identified.

Zone-melting also is being used as a research tool for laboratory investigations of the effects of impurities on various materials, as well as in manufacturing applications.

## Business Opportunities in Atomic Energy Discussed

"Business Opportunities in Atomic Energy" was the theme of the 2-day meeting of the Atomic Industrial Forum held at the Biltmore Hotel, New York, N. Y., March 15–16, 1954. Papers were presented at the five sessions which traced the progress made up to date in the atomic energy field—what is being made available to industry—and what can be expected soon.

The morning and afternoon sessions of the first day were devoted to uses of radioactive materials and potential industrial applications of atomic energy, respectively. Such subjects as an atomic-powered locomotive, cold sterilization, and applications in the pharmaceutical industry were considered in the afternoon.

At the evening session, over which W. L. Cisler, president of both the Atomic Industrial Forum and the Detroit Edison Company, presided, five of the country's nonprofit atomic research facilities available to industry were described. These facilities are Brookhaven National Laboratory, University of Michigan Phoenix Project, Stanford Research Institute, Battelle Memorial Institute, and Armour Research Foundation.

Consulting and nuclear engineering services were considered at the following day's morning session and also the government services available to industry. Four papers under this last-mentioned heading described the Atomic Energy Commission's industrial participation program, the classification system, its industrial information services, and the isotopes services.

New materials, fluorocarbons, and zirconium were discussed at the opening of the afternoon session and were followed by four papers on products required by the atomic energy program—products needed by reactors and related facilities; those required by the Atomic Energy Commission; the commission's contracting procedures, and the assistance given to contractors and their suppliers.

The Atomic Industrial Forum, Inc., was organized last fall and its main office is at 260 Madison Avenue, New York, N. Y.

# LETTERS TO THE EDITOR

**INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.**

## Force on a Conductor in a Slot

*To the Editor:*

Reference is made to two letters by Cahn and Spence of Syracuse University, on the subject of the force on a conductor embedded in ferromagnetic material in a magnetic field (*EE, May '52, p 485; May '53, pp 474-5*). These letters describe measurements and mention a mathematical analysis, purporting to prove the commonly accepted view that the ferromagnetic material in which the conductor is embedded so shields the conductor by "shunting" the "flux" that the force on the conductor due to the original field is greatly reduced, but that a force corresponding to the reduction reappears between the enclosing ferromagnetic material and the field.

In making their measurements with the conductor embedded, Cahn and Spence were dealing with a 3-body problem in which all forces are in a single straight line, perpendicular to the conductor and the axis of magnetization. Their measurements gave the net force on one body due to the other two, but contained no clue as to how this net force should be divided into components. In giving the division which they stated, they introduced a preconceived result and thereby arrived at a conclusion that was not warranted by the measurements they had made. Their statement that they had made a boundary analysis which supported their conclusion really does not add to the validity of their claim, because in boundary analysis it is necessary to introduce boundary conditions which usually are made to conform, in advance, to most of the results the analysis is supposed to demonstrate. There are well-known and commonly accepted electromagnetic concepts which indicate that the division of force into the components which Cahn and Spence assumed was wrong; and that the net force on the embedded conductor is made up of the original force without the enclosing sleeve, *minus* an oppositely directed force of nearly equal magnitude, between the conductor and the sleeve, when the latter is introduced. The following comments show how this result is arrived at:

The present-day concept of "magnetic domains" teaches that any elementary cross section of a ferromagnetic material consists of very small regions which act like magnetic dipoles and become oriented in response to a magnetic field. This is not much different from the molecular currents expounded by Ampere over a century ago. The net result by either concept, when the cross section is at right angles to the axis of magnetization, is that a summation, over the entire surface of the cross section, of the external effect of all the local actions, is equivalent to substituting an electromagnet consisting of a conductor comprising a single turn and having the shape of the perimeter of the cross section, and carrying an equivalent "peripheral current."

Suppose we apply this concept to the pole pieces which are the source of the magnetic field, and consider the case of the conductor without enclosing ferromagnetic sleeve. If we now introduce the usual analysis of the force between current-carrying conductors, and sum up the result for all elementary lengths of the equivalent "conducting shell" of the pole pieces with respect to the unembedded conductor, it will yield the force under discussion. When the enclosing sleeve is introduced, we merely employ the concept of superposition of fields. This is what Cahn and Spence undoubtedly would object to most in this analysis, but if the principle is correct to apply to any natural phenomenon it is correct to apply here. We must assume consistency, not capriciousness, in nature. By this concept the force on the conductor due to the pole pieces remains unchanged, but we now must investigate the matter of a force between the sleeve and the conductor.

In doing this we first recognize that the magnetic domains of the sleeve become oriented, by magnetic induction due to the pole pieces, in a manner similar to those of the pole pieces. If we take unit cross sections of the sleeve perpendicular to the axis of magnetization, they will resolve themselves into equivalent electromagnets just as the pole pieces did, and likewise must involve forces with respect to the conductor. These cross sections will be of two geometrical patterns: those which are single, and those which are double because the plane on which they are taken passes through the interior opening in which the conductor is located. The first kind are situated with respect to the conductor similarly to those of the pole pieces. That is, the conductor lies *within* their projected area. Therefore the forces can be expected to be in the same sense as those due to the pole pieces. However, in the case of the second group, the double ones, the conductor lies *outside* their projected area. Thus we should expect that the forces would be in the opposite sense, which proves to be the case. Furthermore, these double cross sections are physically nearer the conductor, particularly those portions of the perimeter where the sense of the "peripheral current" is reversed. Thus the application of forces between current carrying conductors yields a relatively greater force for these cross sections. In addition, this force is more nearly in the line of the net resultant of all forces and therefore has the greatest effective component. Thus it will be found that there will be a net force on the conductor due to the sleeve, opposite in direction to that of the pole pieces, and of a magnitude dependent upon the permeability and geometry of the sleeve. As to any force between the magnet and the sleeve, if these two bodies are symmetrically placed on the axis of magnetization, analysis on the basis of the force between current carrying conductors yields no force in the direction under consideration. If the sleeve is located equidistant between the two poles of the magnet, it will be in unstable equilibrium with respect to attraction toward either pole. If not equidistant, it will experience a net force of attraction toward the nearer pole, this being the usual attractive force of magnetism and not related to the problem under discussion.

These, then, are the conclusions we arrive at by embracing and applying without bias well-known and commonly used principles which are the very fundamentals of both engineering and scientific analysis, the references offered in Cahn and Spence's second letter notwithstanding. These references are a good example of how erroneous ideas are perpetuated. Electromagnetism took a wrong turn back there somewhere about the time of the sources quoted by those references, stemming from the invention of the "line of magnetic flux" which Michael Faraday introduced purely as an aid in visualizing the action, not the fact, of electromagnetic phenomena. It would seem that it would be well to subject the entire range of magnetic phenomena to a critical review.

W. A. TRIPP (M '35)

(Ebasco Services, Inc., New York, N.Y.)

*To the Editor:*

In a foregoing letter, Mr. Tripp comments on the method of analysis and interpretation of results presented in two earlier letters of ours on the subject of forces in electromagnetic apparatus. Since the analysis and interpretation Mr. Tripp proposes in place of ours is quite acceptable to us except for minor details, our primary purpose in this letter is to offer our endorsement of his approach.

Our main point in this connection is that in our presentation of fundamental electromagnetic phenomena, we should give emphasis to the fact that the total, net magnetic force on an iron-copper configuration exists mostly on the iron rather than on the enclosed copper, even though the current is in the copper only. We assume from his letter that Mr. Tripp agrees with the physical fact and would agree enthusiastically that it deserves emphasis.

We had not meant to imply uniqueness in the theoretical analysis we presented, and we certainly did not mean to imply a physically demonstrable validity of the mechanical model of the "ether" with its "marvellous properties" which Hague refers to. As Mr. Tripp says, the domain theory and the concept of magnetic polarization or magnetization are quite well established, and they provide by far the most satisfactory physical picture of magnetic phenomena in ferromagnetic media which is so far available to us. We can not be quite as unreservedly enthusiastic about the complete adequacy of the domain and magnetization theory as Mr. Tripp appears to be. We are not aware that man ever yet has been able to produce a mental picture of physical phenomena which did not break down when the microscopicness of examination or the range of the variables was extended without an arbitrary limit. The outstanding example of this behavior is in mechanics, of course, where Newton's Laws suggest a marvelously simple, logical, and complete picture of mechanical phenomena—a picture which in the face of experimental evidence must be modified when the velocities approach that of light and which seems to break down completely when applied to atomic and subatomic phenomena.

Although its appeal to our sense of logic and order is pertinent in judging the quality of a theory, its final standing would seem to be based on how much assistance it gives us in registering and predicting the behavior of the physical world. The writers agree with Mr. Tripp that the use of the magnetic polarization concept in ferromagnetic studies probably will be found to be increasingly helpful to us in the future. If this concept and theory are worth while, no doubt their use by Mr. Tripp and others in solving problems will be demonstrated in future publications. As a matter of fact, in his letter Mr. Tripp uses the magnetization analysis very effectively to show that the vector sum of the forces on the wire and concentric iron sleeve must be constant, regardless of the permeability of the sleeve.

On the other hand, the flux concept predicts accurately and with the utmost simplicity the diminution of force on the conductor with an increase of sleeve permeability. Because of the great usefulness of the flux concept in many such cases, we suggest that it perhaps can be given a respectable basis as follows:

As a first step, we will agree that "flux" does not "exist" and that it does not "cause" anything. We define the **B** vector in terms of physical force measurements, which can be made in theory at least. Next we define the flux $\phi$ of the vector **B** across a surface $S$ as the surface integral of **B** over $S$—an exclusively mathematical operation. Now we construct a *tube of flux* by passing lines through all points on the boundary of $S$ and requiring that each line shall be parallel to **B** at each point along its length. Then from Gauss' Law we can get an idea of the strength (and direction) of the **B** vector at any given point $P$ by observing the cross-sectional area (and direction) of the tube of flux in the vicinity of $P$. From the definition of **B** we can predict correctly the force on any filamentary current near $P$. The question of *why* the force exists is irrelevant in addition to being ultimately unresolvable. Similarly, for physical bodies the stress tensor calculation can be applied[1] to predict correctly the measurable net force on the body without raising any questions about the nature of the mechanism of the force.

As a minor point, we suggest that Mr. Tripp did not carry his analysis quite far enough. He found components of force between the three bodies considering the magnetization of the iron in the sleeve due to the permanent magnet only. Should he not have shown also, as easily can be done, that the magnetization in the sleeve due to the current in the wire results in no net change in the components previously found?

D. W. SPENCE (AM'50)
C. R. CAHN

(Electrical Engineering Department, Syracuse University, Syracuse, N.Y.)

REFERENCE

1. Electromagnetic Theory (book), **J. A. Stratton.** McGraw-Hill Book Company, Inc., New York, N.Y., 1941, pp. 153–5.

## NEW BOOKS • • • • •

**The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.**

A HISTORY OF THE THEORIES OF AETHER AND ELECTRICITY. The Modern Theories 1900–1926. By Sir Edmund Whittaker. Philosophical Library, 15 East 40th Street, New York 16, N. Y., 1954. 319 pages, 9½ by 6½ inches, bound. $8.75. Continuing the survey, of which volume 1 covered the classical theories, the present volume describes the revolution in physics which took place in the first quarter of the 20th century. Major developments covered are the special relativity theories, the older quantum theory, general relativity, matrix mechanics, the wave mechanics. The important contributions are documented and discussed in logical groupings. A third volume will cover 1926–1950.

LEADERS IN AMERICAN SCIENCE, 1953–54. Edited by Robert C. Cook. Who's Who in Education, Inc., 110 Seventh Avenue North, Nashville, Tenn., first edition, 1953. 703 pages, 9½ by 6¼ inches, bound. $12. The first volume of an intended biennial series, this directory lists some 13,500 scientists, with biographical information when supplied, and in some cases, photographs. Among those included are all fellows of national science organizations; all members of the National Academy of Science, Sigma XI, and similar organizations; and hundreds who were personally recommended by other scientists. A special feature is a classified list of men and women selected as the most distinguished in their fields by a poll of scientists.

# INDUSTRIAL NOTES ....

**General Electric News.** As a result of forecasted higher demands for large industrial control equipment, General Electric plans to build a new multimillion dollar plant in Roanoke County, Va. The transfer of the department from Schenectady, N. Y., to the new 100-acre site will release facilities for the scheduled expansion of other departments in line with future plans for the Schenectady Works.

Edward E. Bauer has been appointed superintendent of regulator manufacturing for the company's power transformer department at Pittsfield, Mass. Mr. Bauer was formerly manager of transformer apparatus sales.

Samuel N. Johnson has been named project engineer at the chemical materials department's phenolic products plant at Pittsfield, Mass.

Austin F. Leach has been appointed manager of product service for the company's welding department. In his new post he will be responsible for developing techniques to reduce maintenance, increasing availability of renewal parts, and for general service to customers on all products of the department.

Two appointments in the marketing section of the silicone products department have been announced. William S. Kather was named supervisor, water-repellent silicone sales development; and Milton C. Lauenstein was appointed supervisor of the rubber fabricating industry sales development.

Henry J. Digeser has been named process engineer at the chemical materials department's phenolic products plant in Pittsfield.

Lee K. Alexander has been appointed manager of marketing for the light military electronic equipment department. Mr. Alexander will have his headquarters at the department's new plant in Syracuse, N. Y.

V. M. Lucas has been appointed manager of marketing for the company's heavy military electronic equipment department in Syracuse. The appointment follows the integration of government marketing activities with other operations of the military department.

Donald E. Perry, formerly industrial sales manager, has been appointed clock sales manager, and John H. MacLeod, formerly industrial sales engineer in the Middle West, has been appointed industrial sales manager.

**New Lapp Insulator Building.** Lapp Insulator Company, Inc., has started construction on a new high-voltage laboratory at their Le Roy, N. Y., plant. The laboratory will be called The John Lapp High-Voltage Laboratory. When completed in July, the new laboratory will have facilities for 60-cycle testing at 1,000,000 volts and impulse testing at 2,500,000 volts.

**Treasurer Named.** E. A. Hengst of Westfield, N. J., has been named treasurer of the American Gas and Electric Company (AGE). He also has been named treasurer of all AGE subsidiary companies, including the AGE Service Corporation. Associated with the company since 1930, Mr. Hengst succeeds Alfred E. Craig who died December 26, 1953.

**Burndy Appointment.** Burndy Engineering Company Inc., Norwalk, Conn., manufacturers of electric connectors, has announced the appointment of Alan E. Aune as supervisor of a new sales group devoted exclusively to manufacturers of electric equipment.

**New Acme Officers.** Curtis F. Falldine was elected treasurer and Carl J. Anderson secretary, at a recent meeting of the board of directors of the Acme Electric Corporation. Mr. Falldine joined Acme in July 1953 as controller. Mr. Anderson began his employment with the company in December 1944 as supervisor of the payroll department.

**Allen-Bradley Appointment.** Richard Wessling, formerly vice-president and director of Electric Supply Corporation of Chicago, Aurora, Hammond, and Milwaukee, has been appointed district manager of the Chicago, Ill., office of the Allen-Bradley Company of Milwaukee, Wis. He succeeds John McC. Price, former district manager, who retired.

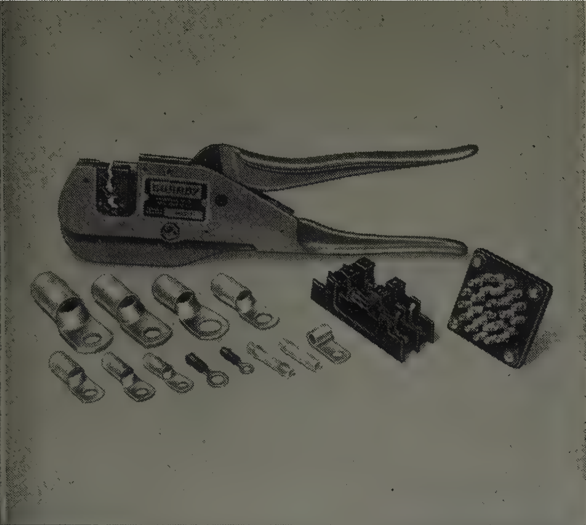
**Okonite Company Absorbs Subsidiary.** The Okonite Company of Passaic, N. J., manufacturer of insulated wires and cables, has announced that effective April 1, The Okonite-Callender Cable Company, Inc., its wholly owned subsidiary, will be merged with the parent company. This corporate change will make possible the streamlining of certain operations and, at the same time, will eliminate the duplication of effort that was required while handling that manufacturing plant as a separate organization. The trade-marks "Okonite-Callender" and "Okocal" will be retained to identify the paper-insulated power cables and splicing materials produced. There will be no change in personnel or products.

**District Manager Named.** Theodore Ulrich has been appointed Chicago, Ill., district manager of sales and service for the Nickel Cadmium Battery Corporation. His headquarters will be at 122 South Michigan Avenue.

**Sylvania News.** Sylvania Electric (Canada) Ltd., a wholly owned subsidiary of Sylvania Electric Products Inc., have announced plans for construction of a new plant in Dunnville, Ont., Canada, where television sets will be manufactured.

Sylvania Electric Products Inc. commenced manufacturing operations on its new 422,000-square-foot television set assembly plant in Batavia, N. Y., the company's largest facility under one roof.

(*Continued on page 18A*)

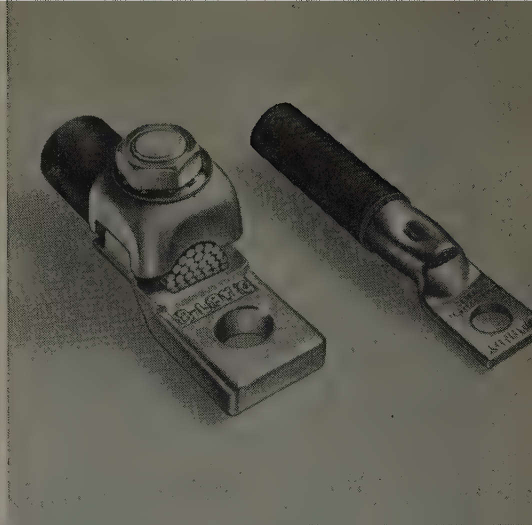


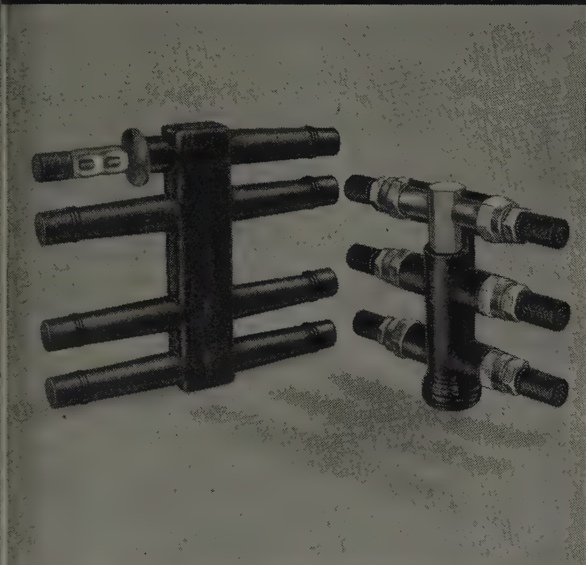
◀ **AIRCRAFT**

Modern jet aircraft as well as conventional high-altitude planes incorporate Burndy Hydent connectors, Pressurized Disconnect Panels, and Limiters as integral parts of their electrical systems.

**BUILDING** ▶

Engineers responsible for planning and maintaining electrical systems of homes, offices, industrial plants count on Burndy for trouble-free electrical connections. Burndy Qiklugs, Scrulugs, Hylugs...dependable names to remember.



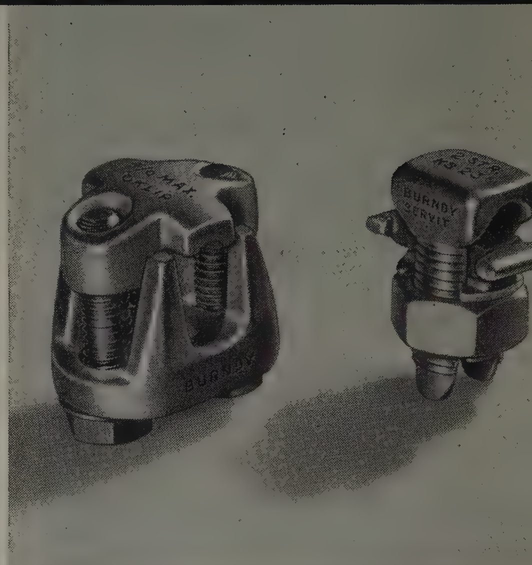


◀ **UNDERGROUND**

Burndy Moles and Molimiters provide maximum circuit protection, unlimited possibilities for underground system expansion. Burndy tools permit speedy, safe, economical installation in tight quarters.

**DISTRIBUTION** ▶

Service connections are made with a variety of Burndy connectors. The Burndy Servit and Oklip are the most widely used and re-used connectors in America. Burndy compression connectors—and matched tooling—are coming into increasingly wide use.



# N D Y

In the production, transmission, consumption of power...wherever current flows... you'll find Burndy connectors on the job—joining, terminating, clamping or protecting the circuits which enable electricity to do the work of man. The Burndy line is the *engineered* line, with specialized connectors for every industry using electrical current—and that means *every* industry in America.

If your job involves connectors—write Burndy for technical counsel for complete, professional catalogs covering your specific field.

**FACTORIES:** NEW YORK, CALIFORNIA, TORONTO • **EXPORT:** PHILIPS EXPORT COMPANY 53-27

(*Continued from page 14A*)

**Manager Named.** George G. Halfinger, assistant superintendent of the Connecticut Light and Power Company's Montville (Conn.) Plant, has been named head of the Ohio Valley Electric Corporation's (OVEC) Kyger Creek Plant at Cheshire, Ohio. Expected to begin production of electric power about March 1955, the plant will be the largest in Ohio and will have a total generating capacity of 1,000,000 kw. Kyger Creek and its sister plant, the 1,200,000-kw Clifty Creek Plant at Madison, Ind., are being built by the OVEC to supply the tremendous electric power requirements of the U. S. Atomic Energy Commission's Portsmouth Area Project.

**Ford Instrument Appointments.** Professor Theodor Buchhold, scientist, author, teacher, and formerly chief of the guidance and control branch of the Guided Missile Development Division of Redstone Arsenal, has joined Ford Instrument Company, Division of The Sperry Corporation, as staff consultant to the vice-president for engineering. Dr. Buchhold will specialize in research and development projects.

Kenneth Slawson has been appointed assistant to the president of the company, and will be concerned with general administrative problems.

**RCA Victor News.** Entry into the railroad communications equipment field by the Engineering Products Division of the Radio Corporation of America (RCA) has been announced. RCA has available for immediate delivery a complete line of microwave radio-relay equipment, meeting the specific and unusual requirements of the railroads for supplementing or even supplanting existing open-wire line communications systems.

H. C. Edgar and Albert F. Watters have been appointed to the newly created administrative positions in the RCA International Division. Mr. Edgar, formerly merchandising director of the division, was promoted to director of export. Mr. Watters, formerly vice-president in charge of personnel for RCA Victor Division, was promoted to director of Associated Company Operations for RCA International Division.

Robert W. Conner has been appointed to the newly created post of manager of the installation and customer section, Broadcast Marketing Division, RCA engineering products department. In his new position, Mr. Conner will co-ordinate field installation, customer service, and warranty problems, formerly a function of the broadcast commercial operations section.

## NEW PRODUCTS . .

**Recording System.** A recording system capable of continuously logging conditions found in multiples of 48 to 144 points,

(*Continued on page 22A*)

# INSULATOR STRENGTH

# NEW MICROGLAZE*

## SUSPENSION INSULATORS

An insulator's ability to withstand mechanical impact varies with thickness of the compression glaze on its surface. Too much glaze . . . or too little . . . will prevent full development of insulator strength.

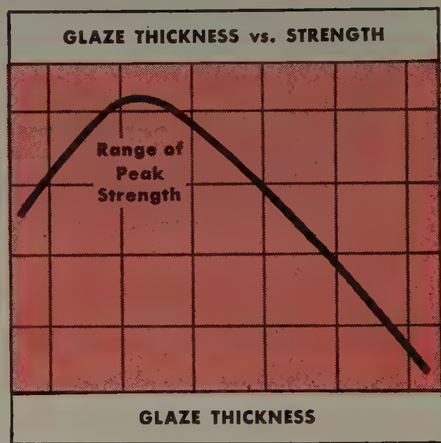
*However, laboratory tests show that porcelain with a smooth coat of compression glaze, held within a microscopically narrow range of thickness, will be as much as 40% stronger than improperly glazed porcelain.*

Locke has been quick to bring this discovery out of the lab and onto the production line for the benefit of all insulator users.

The result is the new MICROGLAZE Suspension Insulator.

Microscopic control of glaze thickness is now applied to these mass-produced suspension insulators, resulting in uniform peak strength, assuring you a new kind of protection . . . and longer, trouble-free insulator service life.

Next time specify MICROGLAZE Suspension Insulators . . . your best insurance yet against the hazards of mechanical impact.

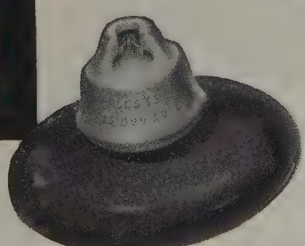



Research in Locke laboratories proves definite relationship between glaze thickness and both flexural and impact strength of the porcelain. Curve shows how impact strength increases with increasing glaze thickness, reaches peak, then drops sharply. On Microglaze Insulators, glaze thickness is maintained within the narrow range which gives *peak* strength.

Accurate glaze thickness control is accomplished by use of this precision glazing machine. As each insulator spins its way around the wheel, it is cleaned, moistened, glazed, exactly the same way as every other. This, combined with special control of many other factors assures uniform appearance, uniform top strength, uniform reliability.

**Send today for new 8-page folder titled "The Story of Microglaze Insulators"**

# LOCKE



**LOCKE DEPARTMENT**
**GENERAL ELECTRIC COMPANY**
**BALTIMORE, MARYLAND**

*Trademark of General Electric Company

(*Continued from page 18A*)

at the rate of a point every 1 to 5 seconds, has been developed by the Industrial Division of Minneapolis-Honeywell Regulator Company. The new multipoint logging system was especially designed for testing and research applications where a record of all measurements is required. It has a single set point as contrasted to the firm's more expensive, elaborate electronic scanning system which has one set point for each group of nine points and which scans and logs up to 270 points. There are two types of the new system: a 24-volt d-c system and a 115-volt 60-cycle a-c system. Special arrangements are available to modify the new system for some double-range calibration.

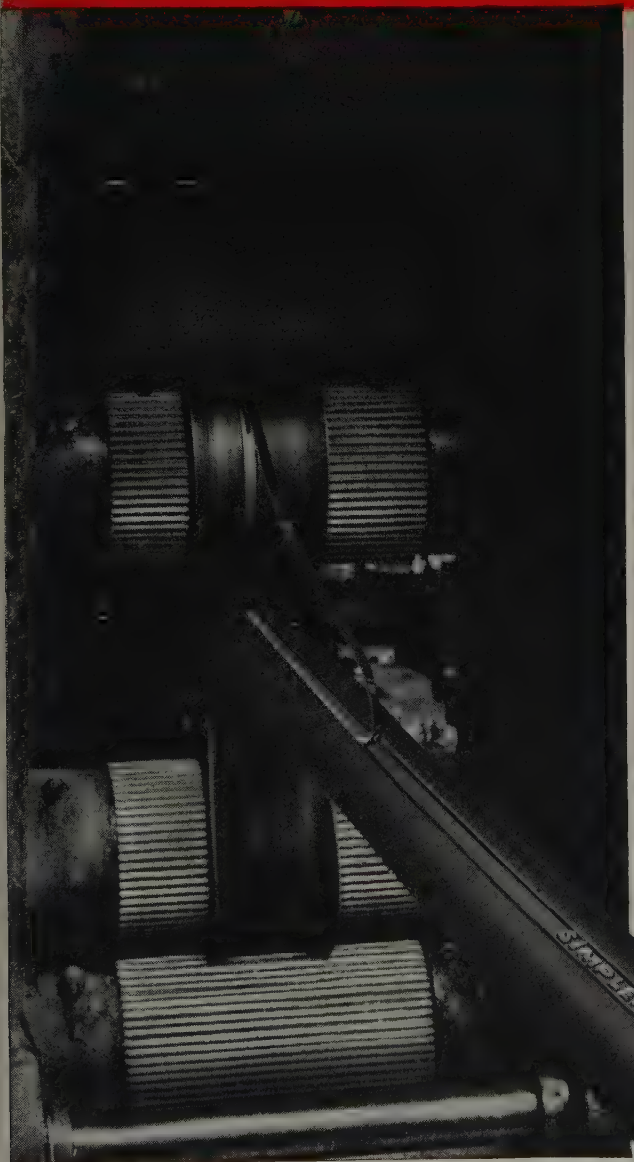
**Waterproof Power Plug and Receptacle.** A new rapid disconnect power plug and receptacle, numbers *20295-1* and *20296*, for use on tractors, trucks, busses, stationary engines, oil field, heavy industrial marine, or ordnance equipment, or other portable or stationary prime power sources has been announced by Cannon Electric. The fittings carry two 200-ampere contacts for number 0 cable with 110-volt to 440-volt service. The cable entry is watertight sealed with a screw-tightened clamp. Special Bulletin *PR-GB1* is available upon request from the factory catalogue department, Cannon Electric Company, 3209 Humboldt Street, Los Angeles 31, Calif.

**Receiving Tube.** Development of four new receiving tube types for color television sets was announced by the General Electric tube department. The new types are the *2V2* high-voltage rectifier, the *5AU4* high-output full-wave rectifier, the *6AR8* sheet-beam synchronous detector, and the *6BU5* high-voltage pentode for shunt regulation. The *2V2* is a filamentary diode intended primarily for use in flyback types of power supplies. Its high inverse voltage and peak current capabilities make it suitable for use as the high-voltage rectifier to supply power to the anode of a color picture tube or to a monochrome picture tube which operates at high anode voltage. The *5AU4*, a twin diode, is designed for use in the power supply of television receivers and other equipments which have high output current requirements. The *6AR8* is a double-anode sheet-beam of deflection tube designed primarily for use as a synchronous detector in color receivers. The *6BU5* is a low-current high-voltage beam pentode designed primarily for use as a shunt voltage regulator in the high-voltage power supply of color television receivers. Further information on the four types may be obtained from the General Electric tube department, Schenectady 5, N. Y.

**Cathode-Ray Oscillograph.** A new wide-band cathode-ray oscillograph, featuring high-precision measurement of both time and amplitude over the entire range of general laboratory applications, has been announced by the Instrument Division of

(*Continued on page 36A*)

# If it isn't SIMPLEX ...it isn't TIREX!




**TIREX** is a registered trade-mark and is the property of the Simplex Wire & Cable Co. Only Simplex makes TIREX. TIREX Cords and Cables were the first to have a hard service rubber jacket. All other rubber-jacketed cords and cables came after TIREX was developed.

Every foot of TIREX Cords and Cables has a *cured-in-lead* selenium-neoprene armor to provide long life. This is what you expect from the cords and cables you buy. This is what you get with TIREX.

For more than thirty years TIREX Cords and Cables have been steadily improved. Today, they combine the famous *cured-in-lead* process with an extra-tough selenium-neoprene armor that can withstand even the toughest assignments.

Remember when you buy cords and cables, if it isn't Simplex, it isn't TIREX.

**More complete information may be obtained from your nearest Simplex distributor or by writing to the address below . . .**

## *Simplex* WIRES & CABLES

....... SIMPLEX WIRE & CABLE CO., 79 Sidney Street, Cambridge 39, Mass.


(*Continued from page 22A*)

Allen B. Du Mont Laboratories, Inc., Clifton, N. J. The new instrument is designated the Du Mont Type *323*. The direct-coupled 10-mc (3 db down) vertical amplifier of the Type *323* enables display not only of very-low-frequency phenomena, but also of high-speed pulsed, together with their d-c level. A technical bulletin with complete specifications for the oscillograph is available upon request from the technical sales department, Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Avenue, Clifton, N. J.

**New Integrating Instruments.** Two new integrating instruments, one current-integrating and the other current-squared integrating, have been announced by the General Electric Company's meter and instrument department. Designed to reduce statistical analysis to a simple slide-rule calculation, the instruments are designed for the solution of quality control problems encountered by the manufacturers of yarn, wire, strip metals, photo film, rope, plastics, and similar products in continuous moving processes.

**Precision Capacitors.** Intended for use in substitution methods of measurement, the General Radio Company's Type *722-MD* and *-ME* precision capacitors are calibrated in terms of capacitance difference rather than terminal capacitance. For convenience in use, the scales read directly the capacitance removed from the circuit. Each model has two sections, one section having one-tenth the range of the other. The Type *722-MD* has capacitance-difference ranges of 0 to 1,050, and 0 to 105 micromicrofarads, and the Type *722-ME* ranges of 0 to 105, and 0 to 10.5 micromicrofarads. This is the first time a 10-micromicrofarad model has been available except on special order.

**Color Demodulator Tube.** A new pentode amplifier tube, Type *6DB6*, designed for use as a color demodulator synchronous detector in color-television circuits has been announced by the Westinghouse Electronic Tube Division. One advantage of the new tube is its capability of being driven harder and giving larger outputs than tubes currently being used as color demodulators. The *6DB6* is a sharp-cutoff pentode amplifier of the 7-pin miniature type. Grids *1* and *3* are control grids for color demodulator use. The chromatic signal is applied to grid *1* and the output of the 3.58-mc oscillator is applied to grid *3*. The tube output, when used as a color demodulator, is linear for high levels of grid *3* drive.

**Magnetizer.** An impulse magnetizer for magnetizing odd-shaped pieces has been developed by the Raytheon Manufacturing Company. It is designed to magnetize shapes that cannot be processed with an electromagnet, including those in which the reluctance of the air at the open end is less

(*Continued on page 46A*)

Victor Tunnel Kiln No. 2—
(end and side view)

Tunnel Kiln Operating Mechanism

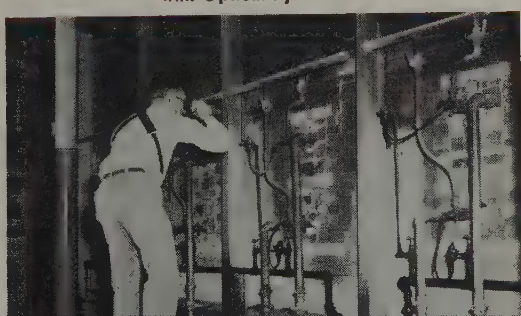


VICTOR NO. 245-R
(EEI-NEMA Class 56-3)
TRANSMISSION PINTYPE



Loaded Car Entering Tunnel Kiln

Checking Kiln Temperatures
with Optical Pyrometer



Tunnel Kiln Control Panel

(*Continued from page 36A*)

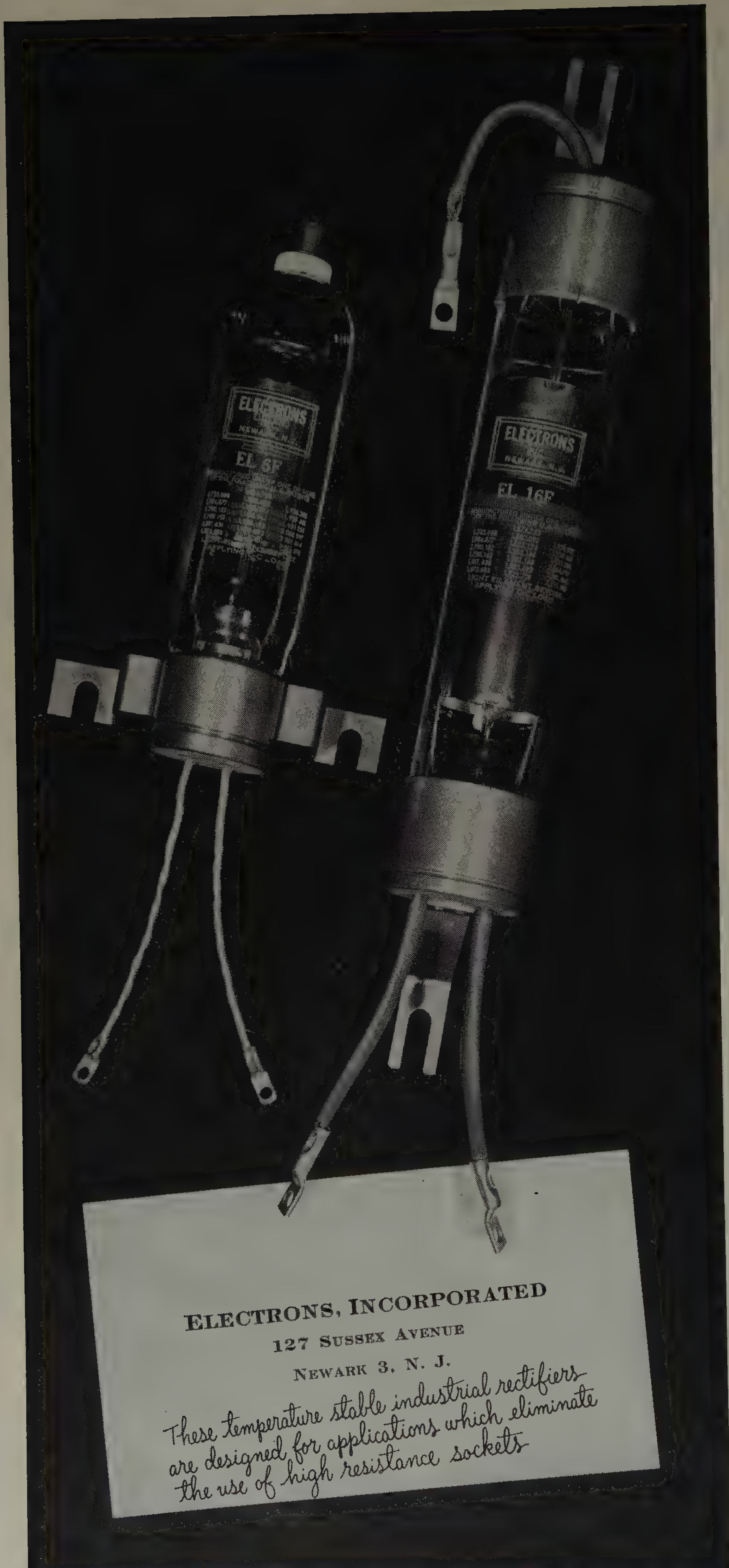
than the reluctance of the magnetic material, as well as completely closed circuits. Named the Raytheon Model *8100* Magnetizer, the equipment processes magnets used in such items as magnetron tubes, microphones, speakers, meters, precision instruments, electro-cardiograph and electro-encephalograph equipment, aircraft instruments, and ore-separating units. The equipment is unique in that it is exceptionally economical of power. Its input power requirement is only 220/440 volts, 32/16 amperes (maximum), 60 cycles single phase. For further information regarding the Raytheon Model *8100* Magnetizer, write to the Raytheon Manufacturing Company, Equipment Sales Division, Waltham 54, Mass.

**Railroad Microwave Systems.** Microwave radio-relay equipments designed to meet the specific requirements of the railroads is now available. Designated as the RCA *CW-20* and RCA *CW-5* microwave systems, they are designed to work with standard-railroad-type telephone and telegraph carrier equipment. The RCA *CW-20* equipment, which operates in the 2,000-mc band, is intended for long-haul multichannel backbone microwave radio-relay systems. It is capable of handling up to 25 telephone channels, plus 20 Teletype channels. As a companion line, the RCA-*5* microwave system operates in the 950-mc band for short-haul service, and is intended for handling up to six voice carrier channels. Complete technical information and assistance in systems planning may be obtained by contacting the Railroad Communications Marketing Section, Building 15-2, Radio Corporation of America, Camden 2, N. J.

**Resistor.** Dale Products, Inc., of Columbus, Nebr., announces the production of a new Dalohm "ruggedized" miniature power resistor designed to withstand the utmost in shock conditions. Designated as Dalohm Type *RSE*, the resistors are available in 2-, 5-, and 10-watt sizes. The *RSE*-type resistors are impervious to moisture (95 per cent relative humidity at 40 C for 24 hours); have complete welded construction from terminal to terminal; and have a temperature coefficient of 0.00002 C. Ranges are from 0.05 ohm to 55,000 ohms. Tolerances of 0.05, 0.1, 0.25, 0.5, 1, and 3 per cent are available. Further information may be obtained by writing to the manufacturer.

**High-Temperature Germanium Diodes.** International Rectifier Corporation is now producing a "red dot" series of germanium diodes for high-temperature applications. These diodes have been developed especially for equipment operation at a high ambient temperature and consequently they have far superior forward and reverse characteristics than conventional diodes at high operating temperatures. As the name implies, they may be identified by the

(*Continued on page 52A*)




(*Continued from page 46A*)

special "red dot" marking on the glass housing. Each unit is so exceptionally well sealed that exposure to 95+per cent relative humidity for 500 hours at temperatures from 0 to 85 C, will not appreciably change back resistance or cause appearance of hysteresis. For additional information, write Department 3 NR for Bulletin *ER-191*, International Rectifier Corporation, 1521 East Grand Avenue, El Segundo, Calif.

**New Fluorescent Unit.** A new fluorescent lighting fixture for large-area lighting applications has been designed to accommodate an air-conditioning diffuser in its center. This unit, measuring 61 inches square, utilizes 24 fluorescent lamps in its inverted pyramid, Alba glass-shielded body. Designed for surface mounting, the unit has a 24-inch by 24-inch opening through its depth, with the lamps arranged in tiers on the four sides of this opening. This opening provides insertion of standard dimension diffusers used with air-conditioning ducts. Further information on this unit may be obtained from the Gruber Lighting Company, 125 South First Street, Brooklyn 11, N. Y.

**Pulse Transformers.** A new line of standard and miniature hermetically sealed pulse transformers for digital computer applications has been announced by the Sprague Electric Company. Designed for use in high-speed circuits utilizing pulses of from 0.1 to 20 microseconds duration, the new units provide an exceptional degree of reliability. The miniature Type *10Z* transformers are primarily engineered for use in flip-flop, buffer, pulse amplifier, and gating circuits, with pulse duration of from 0.1 to 0.5 microsecond. The larger Type *20Z* pulse transformers are designed for blocking oscillator circuits, push-pull memory ring driving circuits, and other applications requiring fast rise time with minimum pulse lag and decay, with pulses up to 20 microseconds in length. Complete details and performance data are in Engineering Bulletin Number *502*, available upon request to the Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

## TRADE LITERATURE

**Dynamometer Systems Publication.** A new bulletin on dynamometer systems for testing internal combustion engines, transmissions, torque converters, rear axle assemblies, pumps, fans, electric motors, compressors, and other types of equipment, has been announced as available from the General Electric Company, Schenectady 5, N. Y. The 2-color 12-page publication, designated *GEA-5923*, tells how General Electric d-c dynamometer systems can be used for both motoring and absorption applications.

(*Continued on page 56A*)


Two *truly miniaturized* self-mounting wire-wound power resistors to simplify TV and industrial electronic production. They're ideal for point-to-point wiring, terminal board mounting, and processed wiring boards, where they fit in admirably in dip-soldered subassemblies.

Axial lead Blue Jackets are rugged vitreous enamel power resistors that withstand the severest humidity performance requirements. They are low in cost . . . eliminate need for extra hardware . . . save time and labor in mounting!

Order Blue Jacket Resistors now in any quantity you require. Sprague Engineering Bulletin 111A gives full data on these and all other commercial Blue Jacket Resistors. Send for your copy.

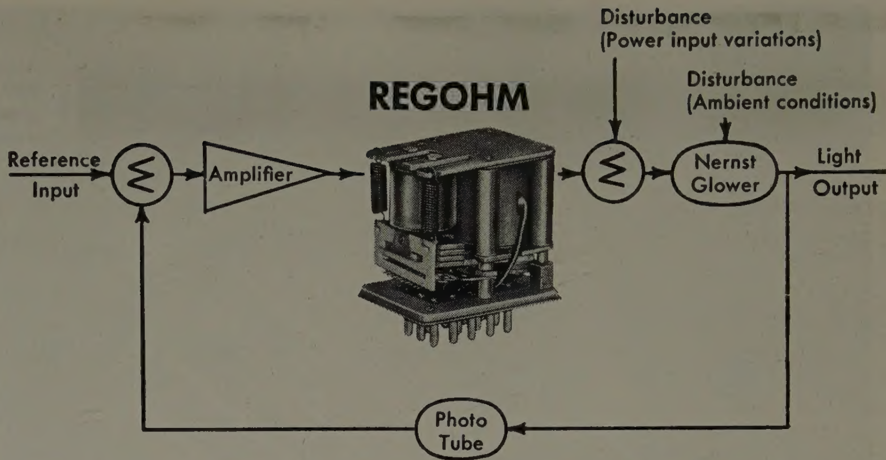
**SPRAGUE ELECTRIC COMPANY**
**321 MARSHALL STREET • NORTH ADAMS, MASS.**

| SPRAGUE TYPE NO. | WATTAGE RATING | DIMENSIONS L (inches) | D | MAXIMUM RESISTANCE |
|---|---|---|---|---|
| 27E | 5 | $1\frac{1}{8}$ | $\frac{5}{16}$ | 17,500 Ω |
| 28E | 10 | $1\frac{7}{8}$ | $\frac{5}{16}$ | 35,000 Ω |

Standard Resistance Tolerance: ±5%

# SPRAGUE

PIONEERS IN ELECTRIC AND ELECTRONIC DEVELOPMENT




# Regohm keeps radiation energy constant for new infrared spectrometers

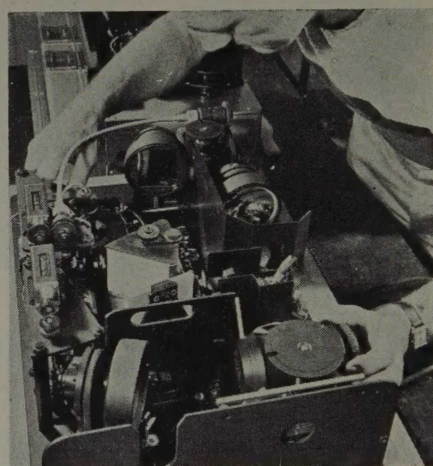
Since infrared analysis must be able to record changes as slight as 1 part in a million of a chemical substance, the energy source must be kept constant. The above block diagram shows how Regohm does this for a Perkin-Elmer Infrared Spectrometer.

In most applications, Regohm directly senses what it controls. Here, however, Regohm serves as a power amplifier. A photo tube acts as the sensing device. Its output is electronically amplified, using a balanced DC amplifier to raise the power level of signal and eliminate the effects of drift.

The photo tube is constantly sensitive to changes from the Nernst glower by delivering current output proportional to changes in radiation. Output from the Reference Balanced Amplifier changes above and below fixed voltage.

Reacting to milliwatt output changes in the amplifier, Regohm produces large changes in power input to the Nernst glower. Hence, the Regohm circuit adjusts for all variations in source intensity, counteracting disturbance from power input changes and ambient temperature conditions. Regohm's dashpot stabilizes the control system.

Electric Regulator takes pride in the fact that high performance alone was the reason for P-E's choice of Regohm for equipment that is the "Cadillac" in its field.



*Assembling a Perkin-Elmer Infrared Spectrometer*

## 7 Reasons why Regohm can simplify your control problem

**1. Regohm is small in size**—It is compact, lightweight, position-free.

**2. Regohm is a high-gain power amplifier**—Milliwatt variations in signal energy control energy changes millions of times greater.

**3. Regohm's isolated signal and control circuits eliminate impedance matching problems**—Signal coils may have ratings from 0.01 to 350 amperes. Control resistance range unlimited.

**4. Regohm will correct system instability**—A reliable, sturdy dashpot aids system damping.

**5. Regohm's effect can be calculated in advance**—Its response is independent of rest of servo system.

**6. Regohm assures continuous control**—In "closed loop" systems a high-speed averaging effect occurs.

**7. Regohm has long life**—Plug-in feature simplifies replacement when necessary.

*Regohm can be applied to your control system or regulation problem. Our engineering and research facilities are always at your service. Write for Bulletin 505.00, analyzing Regohm's characteristics and applications. Address Dept.EN.,Electric Regulator Corporation, Norwalk, Conn.*

**REGOHM**

**CONTROL COMPONENT IN:** Servo systems • battery chargers • airborne controls • portable and stationary generators • marine radar • inverters • locomotive braking systems • mobile telephones • guided missiles • signal and alarm systems • telephone central station equipment • magnetic clutches • railroad communication systems • magnetic amplifiers.

(*Continued from page 52A*)

**Motor Controls.** All motor control users who are concerned with problems of greater economy, safety, and space conservation will be interested in the 12-page "Control Center Folder" recently published by the Arrow-Hart and Hegeman Electric Company. Fully illustrated and containing complete size, rating, and ordering data, this folder provides information of value to manufacturers, plant engineers, and electricians, and all others who buy. specify, or work with motor controls. Copies may be obtained by writing to the Industrial Control Division, The Arrow-Hart and Hegeman Electric Company, 103 Hawthorn Street, Hartford 6, Conn.

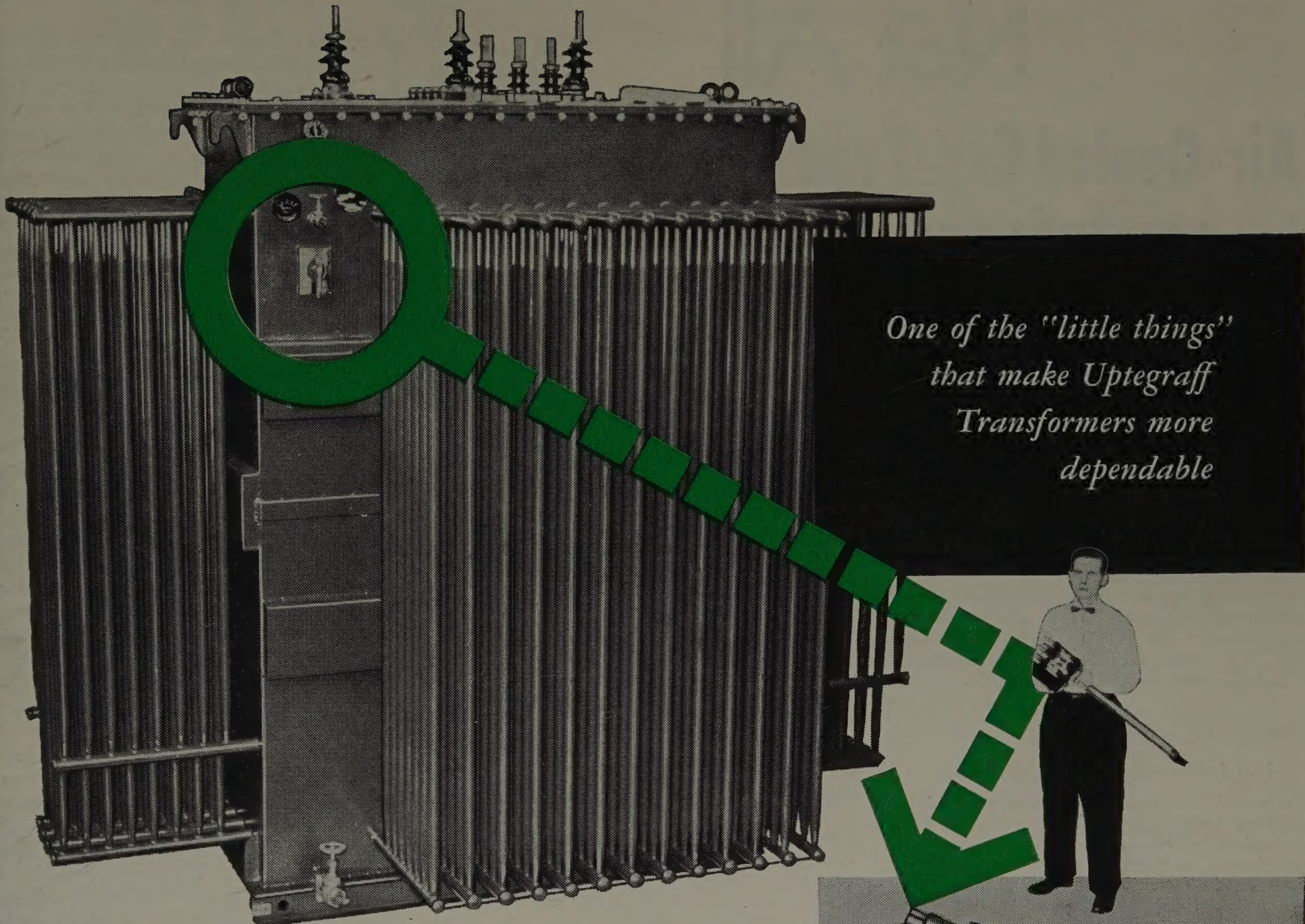
**Holophane's Store Lighting Handbook.** A new Holophane handbook, "Lighting Shopping Centers," has been made available without charge to architects, engineers, contractors, and public utility and store executives. The new guide contains 80 pages of information on the illumination of shopping centers, stores, and supermarkets. The booklet covers every phase of store lighting design; also relighting suggestions where present facilities are inadequate. It is illustrated with 110 store installation photographs, 64 layout plans, and numerous diagrams. A section on lighting fundamentals explains the manner of determining lighting requirements.

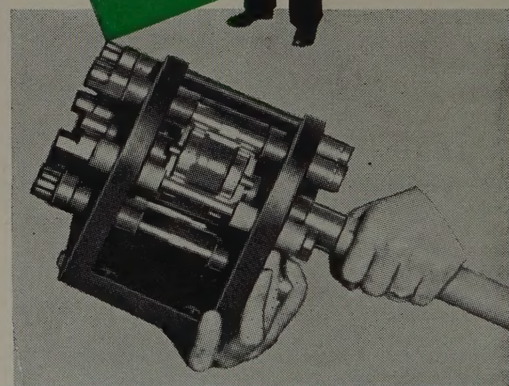
**RCA Sound Catalogue.** A new 20-page illustrated Radio Corporation of America (RCA) sound products catalogue listing the company's latest line of sound equipment, has been published by the RCA Engineering Products Division. The booklet is divided into sections dealing with such sound products as microphones, amplifiers, speakers, intercommunications equipment, television Antenaplex systems, and unit-built cabinets and racks. Each section in turn presents a list of products designed to meet needs from portable systems to large sound installations. Copies of the catalogue may be obtained through local RCA sound products distributors, or by writing to the Sound Products Section, Radio Corporation of America, Camden, N. J.

**Advantages of Preheating Combustion Air.** "The Ljungstrom Air Preheater," a new 36-page booklet now available from Air Preheater Corporation, 60 East 42d Street, New York 17, N. Y., explains the fuel savings and increased performance made possible by using waste heat in flue gases to preheat incoming combustion air. Besides fuel savings of roughly one per cent for every 45–50° of preheat, other advantages explained in the booklet are increased boiler output, more economical boiler designs, and ability to use lower grade fuels.

**Feeder Voltage Regulator Bulletin.** Engineering details of Allis-Chalmers transformer-type 5/8-per-cent step feeder voltage regulators, Type *AFR*, are described in a new 16-page bulletin released by the com-

(*Continued on page 62A*)



# UPTEGRAFF
## tap changers are
## SHORT-CIRCUIT rated as well
## as OVERLOAD rated

This *7500* KVA Uptegraff Transformer is designed and built with a full appreciation of the need for dependability in so-called "little things," as well as in the major parts of transformers.

An example is the Tap Changer shown here. It is rated on the transformer for 60-second short-circuit. It is rated also for normal load and overload operation. Although, as the photograph shows, Uptegraff Tap Changers are sturdy in construction, it is *performance* that counts.

For long life, dependability, and overall economy, specify Uptegraff Transformers.

**Shown above is one of three tap changer switches used for 3-phase power transformers, such as the one at top of the page. Snap-action contact assures positive operation.**

**R. E. UPTEGRAFF**
**MANUFACTURING CO.**

**Scottdale, Pennsylvania**

(*Continued from page 56A*)

pany. The bulletin sets forth the advantages of unit-type construction, one of the exclusive features of *AFR* regulators 750 kva and below. It tells why the unit's shock-absorbing quick-breaking tap-changing mechanism is built to withstand severe operating conditions without servicing. Copies of "Allis-Chalmers Power Regulators," *01B6056D*, are available on request from Allis-Chalmers Manufacturing Company, 931 South 70th Street, Milwaukee, Wis.

**Stainless Steel Booklet.** Allegheny Ludlum Steel Corporation has made available the second edition of its booklet, "Allegheny Metal in Chemical Processing." It is a completely revised 34-page book covering the use of stainless steel in the manufacture of acids and other chemicals, in the general process industries, in the plastics industry, in pharmaceutical manufacture, in dye making, and in soap making. Also included are corrosion resistance data, fabricating information, and a stainless steel finder. Copies may be obtained by writing to the advertising department, Allegheny Ludlum Steel Corporation, 2020 Oliver Building, Pittsburgh 19, Pa.

**Color Broadcast Equipment Catalogue.** The Radio Corporation of America has released to broadcasters and television consultants throughout the country its first catalogue of standard color broadcast equipment, presenting in "package" form all the items required for transmitting network color programs, including test equipment.

**IRC Expands Choke Line.** International Resistance Company, Philadelphia, Pa., introduces two new sizes to its insulated choke line. In addition to a wide extension of ranges, these units are now available in four sizes; all are protectively insulated against high humidity in molded plastic housings. Identified as Types *C1 1/2*, *CLA*, *CL1*, and *CL2*, these chokes offer a wide range of size and characteristic combinations, and permit accurate specification to individual space and electrical requirements. For further information, write International Resistance Company, 401 North Broad Street, Philadelphia, Pa., requesting Bulletin *H-1*.

**Motor Controls.** Of interest to everyone concerned with the motor control problems of the textile industry is a new 8-page promotional folder which has been released by the Arrow-Hart and Hegeman Electric Company of Hartford, Conn. The illustrated folder gives a complete description of the new Arrow-Hart *LM* loom switch said to be the first manual, across-the-line starting switch developed, designed, and manufactured throughout specifically for the textile industry. Copies may be obtained by writing to the Industrial Control Division, The Arrow-Hart and Hegeman Electric Company, 103 Hawthorn Street, Hartford 6, Conn.